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AIRCRAFT ANNOYANCE EVALUATIONS

USING FIELD AND LABORATORY SIMULATION TECHNIQUES

by

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17 Abstract

A series of aircraft noise annoyance evaluation tests was performed under controlled conditions in a laboratory. Jurors drawn from nominal 30-35 NEF zones were exposed to aircraft noise events previously recorded near their homes in the vicinity of the Toronto International Airport and Oshawa General Aviation Airport. Comparison of test results indicates that under optimum simulation conditions both Toronto and Oshawa observers consistently rate the International Airport noise exposure as considerably more disturbing/annoying than those at General Aviation airport sites. The laboratory tests results were also compared with conventional field interview annoyance data obtained for the same group of jurors in a previous study conducted by McMaster University.

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17 Résumé

Des essais visant l'évaluation de la gêne attribuable au bruit des aéronefs ont été faits en laboratoire dans des conditions contrôlées. Des participants, venus de zones exposées à une intensité de 30 à 35 NEF, ont été soumis à des enregistrements de bruit d'aéronefs pris dans les régions de l'Aéroport International de Toronto et de l'aérodrome municipal d'Oshawa desservant l'aviation générale, dont ils sont les riverains. Le bilan comparatif des résultats de ces essais a montré que, dans des conditions optimales de simulation, les participants ont, sans jamais se démentir, coté les niveaux sonores provenant de l'Aéroport de Toronto comme étant considérablement plus perturbants/gênants que ceux provenant d'un aérodrome desservant l'aviation générale. Les résultats des essais de laboratoires ont été également comparés aux données tirées d'un sondage antérieur effectué in situ auprès des mêmes participants, dans le cadre d'une étude conduite par l'université McMaster.

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Abstract

A series of aircraft noise annoyance evaluation tests were performed under controlled conditions in a laboratory. Jurors drawn from nominal 30-35 NEF zones were exposed to aircraft noise events previously recorded near their homes in the vicinity of the Toronto International and Oshawa General Aviation Airports. Comparison of test results indicates that under optimum simulation conditions both Toronto and Oshawa observers consistently rate the International Airport noise exposure as considerably more disturbing/annoying than those at the General Aviation Airport sites. The laboratory test results were also compared with conventional field-interview annoyance data obtained for the same group of jurors in a previous study conducted by McMaster University.

Summary

A series of outdoor listening tests were conducted at the Institute for Aerospace Studies laboratories with prepared aircraft flyover tapes having carefully controlled noise levels and time histories. The test observers evaluating the 30 minute aircraft noise tapes in the controlled laboratory studies were drawn from a larger group of observers included in an earlier extensive field survey, examining for aircraft annoyance and carried out by McMaster University (Ref. 8). The initial objective of the present study was therefore to carry out direct comparisons between the subjective responses of observers exposed to well simulated aircraft flyover noise exposures presented in controlled (laboratory) listening sessions and the field responses, obtained with the same observers, when examining for aircraft flyover annoyance in their actual residential environment.

A second objective of the present study was to examine the hypothesis that in many residential locations impacted by highly variable daily aircraft noise exposures, the subjective response (annoyance) to aircraft noise correlates most strongly with the short term maximum (hourly) noise exposure rather than a longer term (30 day or 3 month) averaged noise exposure. This hypothesis is expected to be most significant for residents located near metropolitan airports experiencing large (but typical) daily aircraft noise exposure fluctuations, due to variable runway usage, aircraft scheduling, and weather conditions.

A final objective of the present test work was to determine whether there were important subjective differences to be obtained for the simulated laboratory listening sessions with observers drawn from residential areas adjacent to major commercial airports and those drawn from residential areas adjacent to smaller general aviation airports. For this test work, a separate set of residential observers, but also previously included in the McMaster field study, were used. Each separate set of observers were exposed to conditions simulating the residential aircraft noise exposures at their own residence and also to conditions simulating the residential aircraft noise from the other airport type (as experienced by the other set of test observers at their residences).

The test observers participating in this study were drawn from residential areas in the vicinity of the Toronto International (Malton) and Oshawa General Aviation Airports. All residential areas used, at both airports, were selected to have a nominal 30-35 long-term NEF exposure. To develop the laboratory listening tapes field recordings were taken at several of these residential sites, at both airports, for both take-off and landing operations. At Malton, it was determined that the aircraft movements were dominated by four aircraft types and these alone were simulated on the final listening tapes in the following proportions:

DC9	47%
DC8	24% (including stretched versions)
Boeing 727	16%
Lockheed 1011	12%

At the Oshawa Airport the operations were dominated by small propeller type aircraft engaged in training and pleasure flying. Field recordings were taken during weekend periods. The aircraft event frequencies used on the final listening tapes were selected so that one of the tapes had the same event frequency that the test observers would encounter at their residences during a peak one hour traffic period. The other three tapes had frequencies twice, one half and one-quarter of the selected peak hour frequency. The peak-period frequency data were obtained from aircraft movement records (DOT) for the period June and July, 1978, for both airports. For Malton a nominal peak-hour frequency of 30/hour was obtained for this period, which agreed quite well with the noted frequencies during field tape recordings (about 12 months later). For Oshawa a nominal peak-hour frequency of 50/hour was obtained, again agreeing reasonably well with field observations.

The test observers were required to attend two evening sessions, in each of which four 30 minute tapes were presented. In the first session observers were exposed to tapes containing airplane signatures appropriate to their own residences. The second series involved aircraft flyover events characterizing the "other" airport. Each test session involved a 20 minute debriefing period, which included the completion of a General Noise Annoyance Questionnaire by each observer. The specific annoyance level for each aircraft tape was evaluated by the jurors on a bipolar scale from +8 to -8, having annoyance descriptors at various annoyance levels in accordance with the evaluation scale used in the prior McMaster field studies. The actual noise levels experienced by the jurors contained a relatively steady background level (air conditioner) in addition to the desired live aircraft noise signals.

The major results and conclusions arising from the present subjective laboratory listening studies may be identified as:

(i) For a given laboratory tape simulation, the 30 minute average subjective evaluations were nearly identical for both residential groups of test observers.

(ii) Carefully planned and executed laboratory simulation testing can yield subjective response results having a high degree of correlation with conventional field-interview annoyance data.

(iii) Although the character of the aircraft noise presented in the laboratory simulations carefully reproduced the actual residential noise exposures at both airport sites, the simulation was significantly more successful for the Malton observers. A major annoyance factor associated with the Oshawa aircraft noise is sleep or relaxation interference, indoors, a condition not simulated in the present tests.

(iv) The test observers have defined the frequency of aircraft events as typical of their own residential exposure as being close to or in excess of the actual peak hour flying frequencies experienced at their residences.

(v) At equal L_{eq} values, the noise exposure adjacent to the larger international airport contains peak levels considerably higher (10 dB) than the peak levels obtained near the general aviation airport. The former noise exposure also contains many periods of extended quiet between aircraft events. This feature is largely absent in the general aviation airport noise exposures. As a result, the total 30 minute noise exposures characterizing the international airport noise exposures were consistently judged (by both observer groups) as substantially less disturbing/annoying than the general aviation noise exposures, at equal L_{eq} values.

(vi) However, at the defined optimum simulation conditions (frequency of events), both sets of observers consistently rate the international airport noise exposure as considerably more disturbing/annoying than those at the general aviation airport sites.

(vii) The combined subjective responses, including both types of airport noise exposures shows excellent correlation ($r = 0.97$) against the time-above-variable (TA) 85. Conversely, the combined subjective responses including results from both airport noise exposures, shows poor correlation against the L_{eq} variable.

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1.0 INTRODUCTION AND BACKGROUND

It is generally accepted, on the basis of a variety of listening tests with noise events of short duration that the subjective response (perceived noise level) is well correlated by means of suitably weighted energy equivalent noise measures such as LEPN or LEQA (equivalent perceived noise level or energy equivalent noise level 'A' weighted respectively). When the duration of the noise exposure is increased the subjective response can shift from that of perceived noise to one of noise annoyance. With longer duration laboratory listening tests, therefore, it should be possible to carry out accurate noise annoyance evaluations of residential noise exposures provided that both the total noise signal, and the other associated significant environmental inputs can be accurately simulated. The required time duration of successful laboratory simulated listening sessions and the degree of sophistication necessary for these sessions are not adequately defined at present, although the earlier work of Borsky, Powell and Rice, and Johnston and Haasz have provided some important inputs to these important problem areas (see Refs. 1, 2, 3).

The overwhelming attraction of the laboratory simulation testing is the precise control that the experiments can exercise over the noise environment evaluated. It is thus feasible to isolate and quantify the physical characteristics which impact the final subjective annoyance evaluations. The alternative field survey technique used in noise annoyance studies suffers drastically from the absence of suitable experimental control so that the separable attributes of the annoyance response are very difficult to identify. To identify separate annoyance effects in the field, extensive measurements must first be carried out over a large community area to confirm that the required test variables are present at the desired test levels.

As an example of the difficulties of identifying (and quantifying) specific noise annoyance effects, the role of the background noise in controlling the total noise annoyance due to aircraft noise signals can be cited. Several controlled laboratory evaluations of the perceived noise response due to carefully simulated aircraft overflight noise signatures have uniformly confirmed a favourable and sizeable reduction in the perceived noise magnitude with increased background noise levels. See, for example, Refs. 3, 4, 5. At least three well documented field surveys have also explicitly examined the influence of background noise on the overall annoyance attributable to aircraft noise. However, results from these field surveys are not in good agreement. Results from the earlier works of Bottom (1971) in the U.K. (Ref. 6), and Grandjean et al in Switzerland (1976) (Ref. 7), appear to confirm the favourable influence of an increased background level. In the more recent field studies by McMaster University (1979) (Hall, Birnie, and Taylor) (Ref. 8), it is concluded that the background noise level has neither a consistent nor significant effect on the overall annoyance due to aircraft noise. In fact, the recent McMaster results would suggest the background annoyance effect to be, in the main, in the opposite sense, so that higher background noise levels result in aircraft noise being rated as more disturbing. These important discrepancies underline the present difficulties experienced in identifying and quantifying specific noise annoyance effects and with making direct comparisons/extrapolations between laboratory and field results. Consequently, an initial objective of the present study was to carry

out direct comparisons between the subjective responses obtained in laboratory listening sessions and the field responses obtained with the same observers, in their actual residential environments. These comparisons were to be obtained by carrying out suitably designed and controlled laboratory aircraft noise listening tests, with observers previously included in an extensive field survey, examining for aircraft annoyance, and carried out by McMaster University (Ref. 8).

A second objective of the present study was to examine the hypothesis that in many residential locations impacted by highly variable daily aircraft noise exposures, the subjective response (annoyance) correlates most strongly with the short term maximum exposure (hourly) rather than a longer term (30 day or 3 month) averaged noise exposure. A similar hypothesis has been examined already in a limited series of laboratory tests by Borsky (see Ref. 9). It is suggested that the maximum hourly aircraft noise exposure at a given residential site will provide a much improved correlation with the measured noise annoyance response. This hypothesis is expected to be most important for residential sites adjacent to metropolitan airports experiencing large (but typical) daily aircraft noise exposure fluctuations due to variable runway usage, aircraft scheduling and weather conditions. This hypothesis was to be checked by presenting to the test observers a series of noise tapes, each with similar mixes of aircraft noise events with equal noise intensities in all cases, but where the total number of aircraft flyover events would be varied over a wide range, including the maximum hourly rate expected at the residential locations of the test observers.

A final objective of the present test work was to determine if there were important (subjective) differences to be obtained for the (simulated) laboratory listening sessions with observers drawn from residential areas adjacent to major commercial airports and those drawn from residential areas adjacent to smaller general aviation airports. For this test work residential observers, previously included in the McMaster field study, examining for aircraft noise annoyance were again to be used. Each separate set of observers was to be exposed in the laboratory to conditions simulating the residential aircraft noise exposures at their own residences from the adjacent aircraft movements and also to conditions simulating the residential aircraft noise from the other airport type (as experienced by the other set of test observers at their residences).

2.0 TESTING PROCEDURES

2.1 Field Recordings

One of the major objectives of this study was to expose the test observers in the laboratory listening sessions to prerecorded noise tapes containing aircraft noise signatures with levels and durations characteristic of the observers' home environment. This was achieved by using real time aircraft noise signatures recorded in the field in residential areas where the test observers have been selected. The test observers participating in our study were drawn from areas in the vicinity of the Toronto International (Malton) and Oshawa General Aviation Airports. All of these areas are located in the nominal 30-35 NEF zones. Field recordings were made at several locations for both take-off and landing operations. However, for the preparation of the final test session tapes only the take-off signatures were used.

Recordings were obtained with the use of a 1/2 inch microphone system and a NAGRA field recorder running at a tape speed of 7.5 in/s. The frequency response at this speed was adequate for the study. At the Toronto airport, recordings were made during morning periods between 8.00 a.m. and 11.00 a.m. During the peak one-hour period the aircraft repetition frequency was about 30/hour. Typical measured levels (linear weighting) for the dominating aircraft types are given below.

Typical measured aircraft noise levels in the 30-35 NEF zone close to runways 5L and 5R at the Toronto International Airport

Aircraft Type	Peak Noise Level (dB)
Lockheed 1011	86 - 94
DC9	89 - 96
Boeing 727	92 - 101
DC8 (stretched)	89 - 91
DC8 (old)	100 - 102

At the Oshawa Airport where the operations are dominated by small propeller type aircraft used for training and pleasure flying, recordings were made on weekends. Typical repetition frequencies were found to be 1/minute, and typical levels (linear weighting) were 80-90 dB. Note that A weighting of the noise produced by these propeller aircraft will result in a level reduction of approximately 7-10 dB.

2.2 Preparation of Session Tapes

As stated above, the final session tapes were constructed using the real time field recorded aircraft signatures. Four tapes were prepared for both the Toronto and Oshawa airport cases. For each site, the tapes contained the same mix of aircraft types, however, a range of differing aircraft event frequencies was used. For the Oshawa tapes, the aircraft type mix used was obtained directly from the field recordings. For Toronto the type mix was determined from Airline Operations Schedules and Runway Utilization Schedules for Terminals 1 and 2 during the summer of 1978. For an evening period of 7.00 - 10.00 p.m. (as our noise simulation test sessions were held in the evenings), the following distribution was obtained:

DC9	47%
DC8	24%
Boeing 727	16%
Lockheed 1011	12%

The aircraft event frequencies were selected such that one of the tapes had the same frequency that the test observers would encounter at their residences during a peak one hour traffic period. The other three tapes had frequencies twice, 1/2 and 1/4 of the peak-period frequency. The peak period frequencies

were obtained from aircraft movement files for June and July, 1978, at both Toronto and Oshawa airports. Considering only commercial itinerant movements and assuming that half of such movements consists of take-off operations, for Toronto we arrive at a nominal peak-hour frequency of 30/hour which agrees extremely well with the field data. For Oshawa, using the total number of movements and assuming that take-offs are half of the total, a nominal peak-hour frequency of 50/hour is obtained, which again agrees reasonably well with field data. The final composition of the test session tapes, each with a duration of 30 minutes, is given below, with the actual session level recordings shown in Figs.3(a) and 3(b) for Oshawa and Malton airports, respectively.

Composition of Final Test Session Tapes

Showing Number of Aircraft Signatures and Types where Applicable

	Toronto Airport					Oshawa Airport
	DC 9	DC 8	B727	L1011	Total	
Tape 1	15	8	5	4	32	48
Tape 2	8	4	2	2	16	24
Tape 3	4	2	1	1	8	12
Tape 4	2	1	1	0	4	6

In order to create the realism of hearing an aircraft approach and then leave during the playback of the tapes, the master tapes were re-recorded on the left and right channels of sterio tapes with a time delay between the two channels. Experimentation yielded best results with a 5 second time delay for the speaker separation and listening area arrangement used for the jury test sessions.

2.3 Selection of Test Observers

One of the objectives of our study was to compare our laboratory simulation results with the field interview results of Hall, Taylor and Bernie (Ref. 8) of McMaster University. To this end we have selected our observers from those who participated in the McMaster study. Because of the complexity of the laboratory simulation, in comparison with field interviews, we could only accommodate a subgroup of the people interviewed by McMaster. We have selected people with medium sensitivity to noise in general from the nominal 30-35 NEF zones around the Toronto and Oshawa airports. The final number of jurors involved in our study was 21 from Toronto and 22 from Oshawa.

2.4 Test Session Procedures

The laboratory test sessions were conducted during the summer months of 1979. This was planned in order to enable a comparison between our test results and the field interview results obtained during the summer of 1978

by the McMaster University group. Our listening area for the listening sessions was set up outdoors at the Institute for Aerospace Studies, simulating a typical home backyard setting. The test sessions were scheduled for evenings in the period between 6.00 and 8.30 p.m. Since this included the dinner hour we have provided the jurors with a Bar-B-Q supper, and thus the test observers' tasks involved light concentration activities, viz., eating and conversation. The resulting effect was quite characteristic of what one might expect in one's own backyard.

The tape playback during the sessions was performed with the use of a TEAC Sterio-tape recorder, a Kenwood model 600 integrated amplifier and four Bose 800 speakers, two connected in parallel for the left and right channels. The amplifier had a capacity of 200 W/channel and this power level was sufficient to reproduce the required aircraft noise levels in the listening area without distortion. High frequency tape hiss was removed with the use of a low pass filter. The speakers were mounted against a wall, at a height of about 2 meters from the ground with a separation distance of 6 meters.

The test observers were required to attend two evening sessions. On the first evening they were exposed to the tapes which contained airplane signatures that were recorded near their own residences, and on the second evening they heard aircraft recorded at the "other" airport. Thus, the Malton observers first listened to aircraft recorded at the Toronto airport, and during the second session, to aircraft signatures recorded at Oshawa airport. The converse was the case for the Oshawa people. The jurors from each airport attended the sessions in groups of 6-12. Thus three observer groups from Malton and three from Oshawa, requiring a total of 12 evening sessions were scheduled in total.

The test session procedures included a twenty minute debriefing period where the jurors were informed of the objectives of the study and the tasks that were required of them during the sessions. During this introduction period they were asked to fill out a general questionnaire (reproduced in Appendix A). The purpose of this questionnaire was to confirm that one of the dominating noise sources in the jurors' home environment is aircraft noise, and also to confirm that during the summer months their awareness of aircraft noise was mainly experienced outdoors, thus validating our outdoor simulation.

Following the debriefing period the test observers were exposed to four noise tapes, each of 1/2 hour duration, during which time they engaged in light concentration activities. After each tape they were required to fill out the questionnaire in Appendix B. Questions 1, 2 and 3 essentially yield a rating of the "annoyance level" for the series of aircraft signatures presented in the 1/2 hour period on a bipolar scale of +8 to -8 with zero being the neutral point. The bipolar scale with the various descriptors was selected in order to be consistent with the scales used in the McMaster field study for the questions for which comparisons between our results and field interview results will be made. In order to answer Questions 1, 2 and 3, the jurors were asked to make an overall assessment of the effect of the total aircraft noise exposure (30 min) they had just experienced. Question 4 was posed in order to test our hypothesis that people tend to remember the "worst repeated noise exposures" at their residences as being typical.

During the playback of the four tapes the total noise environment was monitored and recorded with a 1/2" microphone system and the NAGRA field recorder. The main purpose of this exercise was to check the presence (and levels) of any intruding local aircraft overflights. The background noise level throughout the test sessions was dominated by a window air conditioner adjacent to the listening area which was deliberately turned on to avoid any extremely quiet periods which might attract undue attention to the next airplane events. The resulting background level was about 70 dB (linear). Typical tape recordings during jury listening sessions are shown in Fig. 3(c).

3.0 RESULTS AND DISCUSSIONS

3.1 Aircraft Noise Exposure at Residences of Test Observers

The observers for the laboratory listening tests were drawn from the field interviews carried out (during the prior summer period, 1978) by a McMaster University study group (see Ref. 8). The two groups of observers used were recruited from residential areas adjacent to either Malton International Airport, or Oshawa General Aviation Airport. It was hoped that an adequate number of observers could be obtained at each airport location having a nearly constant NEF exposure. In addition, the test observers were restricted to those having a medium sensitivity to noise as indicated in their response to the prior McMaster interview (Question No. 24) (see Appendix C). This requirement led to a greater spread in the residential noise exposures for the final two groups of observers used (and a larger number of community sites) than was originally intended. Table 1 gives the relevant field data, obtained from the McMaster results for sites covering the twenty Malton observers in the present study. Table 2 gives similar data for the Oshawa observers. In both cases the average McMaster noise annoyance response results (Question 2b, on the numerical scale 0-9), and the total number of respondents at each site are also included. It is seen that the Malton observers' residential site noise exposures spans a range of about 7 NEF units with the maximum exposure being about 32/33 NEF. On average the Malton residential site exposures are 3 NEF units higher than the Oshawa residential exposures.

Additional important information concerning both groups of observers' reactions to their home aircraft noise exposure is obtained by reviewing their direct responsesto the McMaster Survey questions 3, 6 and 7 (see Appendix C). Response to question 3 indicates when (day, evening and night) and where (indoor, outdoor) at home the test observers are most affected by aircraft noise. Question 6 responses indicate what activities at home are interrupted/interfered with by the aircraft noise. Question 7 results give the observer's own estimate of the effects of the noise heard at his residence (from a presented list). The Malton observers' responses to these questions are tabulated in Table 3. [The numerical results for question 3 (when/where data) are given on a scale 0 to 10, with end points only defined as "not at all disturbed" and "unbearably disturbed" respectively.] The corresponding responses for the Oshawa observers for their residences are given in Table 4. The averaged numerical response for both groups to question 3 (when/where data) are plotted in Fig. 1. On the basis of this last information it is readily seen that the laboratory observers have been previously exposed to substantially differing residential aircraft noise exposures with the following significant features:

Malton Observers

Aircraft noise is most disturbing outdoors in the evening and during daytime (almost equally).

- Aircraft noise interrupts speech (conversation) for 81% of the observers.

- Aircraft noise at night is not a factor, nor is sleep interference (airport night curfew).

Oshawa Observers

Aircraft noise is most disturbing at night (indoors).

- Aircraft noise outdoors during daytime or evening is relatively much less disturbing.

- Aircraft noise interferes with sleep for 43% of the observers.

- Speech interference is reported by only 16% of observers.

Thus the aircraft noise exposure for both sets of observers is markedly different and this has a significant impact on the laboratory test work which was designed to simulate a daytime/evening outdoor relaxation environment in which the aircraft noise exposures would be judged. In this situation speech and conversation interference would be a major factor affecting laboratory annoyance judgements. For the Malton observers then, the laboratory environment simulates an annoyance feature which is expected to dominate their noise annoyance at their own residences. For the Oshawa observers, the laboratory listening environment simulates a residential noise exposure which is much less crucial in their expected overall assessment of the aircraft noise annoyance at their residences. The laboratory simulation is therefore expected to be significantly poorer for the Oshawa observers than for the Malton observers. This point will be further explored below.

3.2 Laboratory Response to Simulated Exposures

The averaged half hour subjective annoyance obtained from the laboratory listening sessions for both groups of residential observers is plotted in Fig. 2, against the calculated session L_{eq} values. The sessional L_{eq} values of this figure are not A weighted, being taken directly from a flat recording of the actual outdoor test sessions. The calculated laboratory session exposure characteristics, i.e. L_{eq} (linear), TA_{85} and TA_{80} (see below) are listed in Table 7. Each group of observers judged two separate series of noise exposures. One series, four tapes in number, represented aircraft flyover events at their own residences, a second series of four tapes represented aircraft events at the other airport site.

The four tapes simulating a range of aircraft exposures at any one site all had equal individual aircraft peak levels corresponding to the field recorded values at that site for the particular aircraft simulated, but the number of aircraft events for each of the four tapes were in the ratios 1:2:4:8. For both sites the number of aircraft events so included covered

both the expected average number of aircraft events and the maximum number of aircraft events known to occur at these sites during the summer period; see Section 2.2 above.

The four Malton simulation tapes cover a 30 minute L_{eq} (linear weighting) range from 88 dB to 93 dB, the four Oshawa simulation tapes cover an L_{eq} (linear) range from 77.5 dB to 85.6 dB. Both of these ranges are less than the expected 9 dB range (for the 8:1 frequency range) due to the presence of a significant background level reflecting conversation and other group activities during the session (65 dB ~ 70 dB, unweighted). It is noted that in general the simulated Malton L_{eq} values are considerably higher (about 9 dB on average) than the simulated Oshawa L_{eq} values, reflecting the actual field recorded peak aircraft levels and expected frequencies at these sites.

The data plotted in Fig. 2 show that both observer groups subjectively rate, on average, the aircraft simulations at both sites, extremely closely. However, the score data for each site are distinctly separated, with a separate linear dependence, with L_{eq}, being indicated for each. Thus the best two straight lines, one at each site, are drawn as shown.

This result leads to the unexpected conclusion that at equal values of L_{eq} for the 30 minute noise exposure the Oshawa site simulation would be rated subjectively more disturbing than the Malton simulated noise exposure. A closer examination of the noise tapes and the general character of the noise typical of these sites is therefore warranted. Figure 3(c) shows a typical time history of the aircraft noise simulations obtained during the listening sessions, for both sites. It is seen that the peak event levels for Malton are always considerably higher than those at Oshawa; however the number of aircraft events at Oshawa is substantially larger. Thus at the same L_{eq} values the Malton noise exposure, at least in the range tested here, contains long periods of relative quiet (at the background level). On the other hand, the Oshawa noise exposure is more uniform with time and generally well elevated above background.

The location of the asterisk on the best fit annoyance line for each airport site gives the location where the observer groups indicated a best match between the laboratory simulation of their site noise conditions and their own estimate of the noise condition at their residence. This is determined on the basis of the frequency-of-aircraft events judgement made by each observer for the series of four varying event number tapes presented (see Fig. 5). It is seen that despite the conclusions reached concerning the effects of the general character of the noise exposures at each site (above), the actual Malton noise exposure is rated as much more disturbing/annoying than the actual Oshawa noise exposure, by both groups of observers.

In view of the unexpected results noted above relating to the time character of the signal at constant values of the session L_{eq} parameter, and in an attempt to bring the averaged subjective response from both sites into better agreement, another independent variable characterizing the actual event time history was examined. Thus in Fig. 4 the averaged response is replotted for both sites against the variable $\log_{10} (TA)_x$, where TA indicates the time in seconds that the noise signal remains above a level x, for the total duration of the noise exposure (30 minutes, a constant for all cases). The much improved linear collapse of the average subjective response of both observer groups for both sites strongly suggests that speech interference dominates the factors

contributing to the total subjective response in the present testing. Of the two levels arbitrarily used as datum values for the TA evaluation, the 85 dB level gives a slightly higher correlation with the subjective response. The best linear fit of the present data with TA_{85} and TA_{80} variables, and the related correlation coefficients are as follows:

$$SS_{AVGE} = 10.8 - (0.667)\ 10\ \log_{10}(TA)_{85}; \qquad r = 0.977$$

$$SS_{AVGE} = 14.3 - (0.752)\ 10\ \log_{10}(TA)_{80}; \qquad r = 0.949$$

Both correlations are significant at the 0.1% level and therefore highly significant. (It is noted that the levels used herein are flat weighted, not A weighted.)

Figure 5 shows the variation of the frequency of events judgements, averaged over the group, of the simulated laboratory noise exposures, by the Malton observer group for the Malton (international airport) noise exposures, and by the Oshawa observers for the Oshawa (general aviation) noise exposures. A frequency score of 3.0 is used to indicate a judged equivalence between the laboratory simulation and the estimated actual residential exposure of the observers in terms of frequency-of-events. Since the actual peak levels of aircraft events in the laboratory simulations were equal to those measured outdoors at the two sites, a frequency score of 3.0 then represents the best overall simulation for both airport sites. This optimum simulation for both sites has also been transferred to the averaged subjective score plot of Fig. 2.

3.3 Laboratory Subjective Responses Compared to Field Responses

Since both groups of test observers participating in the present laboratory simulation studies were drawn from a much larger group of respondents participating in an earlier McMaster aircraft noise field study, several important comparisons can be made between the subjective annoyance responses, for the same observers, under field and laboratory conditions. The two groups of observers used in the present laboratory testing both had a nominal size of 20, which is comparable to the size of the groups used in the McMaster field study at each field site (or combined sites). Originally it was intended to limit the participants in the laboratory tests to those having a medium sensitivity to noise generally. This precaution was introduced to avoid the expected erratic response from the extremes in general noise sensitivity (i.e., "not at all sensitive", and "extremely sensitive"), to the changing noise exposure intensities to be used in the laboratory tests. This control was achieved through the field responses obtained from question 24 in the McMaster field questionnaire. In this question a numerical rating from (1) (not at all sensitive) through (5) (extremely sensitive) was obtained from the field respondents with a response of 3 showing moderate or medium general noise sensitivity.

A difficulty arose in attempting to use medium sensitivity observers exclusively for the laboratory work, in that for the field sites of interest the number of observers willing to participate was somewhat less than that required (20). Consequently, a limited number of observers with other

sensitivity responses were used to complete the required laboratory groups. The final compositions (percentages) in terms of general noise sensitivity for the two laboratory observer groups is presented in Table 5. For comparison the percentage distribution of sensitivities for all McMaster field respondents at all sites used to draw the laboratory observers is also given. It is seen that the sensitivity distribution for the Oshawa laboratory observers is in close agreement to that for the total field sample at the same sites. For the Malton laboratory observers, the sensitivity distribution is truncated, with both extremes absent. Thus it is important to examine in greater detail the degree to which the actual laboratory observers are representative of the larger (total) group of field respondents (McMaster study) at the same sites. Thus the averaged field response data obtained from the McMaster field data (Question 2b - 'Aircraft Intensity' 1-9 numerical score) for the selected laboratory observers from a given residential site is compared to the averaged field response for all observers interviewed at that site (all sensitivities). Figure 6 gives a plot showing the laboratory observers' field response compared to averaged field response for all sensitivities, with Malton and Oshawa airport sites grouped separately. The best line linear fit is indicated for both site groups. A linear correlation coefficient of $r = 0.77$ is obtained for the Malton observers' data while an $r = 0.63$ is obtained for the Oshawa data. The former correlation is significant at the 1% level, the latter only at the 10% level.

Perhaps the most important comparison between field and laboratory judgement conditions is obtained by examining the individual responses of the same observers under both judgement conditions. Thus a plot of the 1 to 9 numerical aircraft noise intensity response obtained from the field survey data (McMaster Question 2b) against the laboratory subjective numerical response +8 to -8 (Questions 1, 2 and 3), in the present study, is given in Figs. 7(a) and 7(b) for the two groups of airport sites. It is noted that both numeric scales are directly related since identical intermediate classifications have been employed in both questionnaires as follows:

Field Intensity Scale	Observer Descriptions	Laboratory Intensity Scale
1	Extremely agreeable	+7 & +8
2	Considerably agreeable	+5 & +6
3	Moderately agreeable	+3 & +4
4	Slightly agreeable	+1 & +2
5	Neutral	0
6	Slightly disturbing	-1 & -2
7	Moderately disturbing	-3 & -4
8	Considerably disturbing	-5 & -6
9	Extremely disturbing	-7 & -8

The laboratory test scores plotted in Figs. 7(a) and 7(b) are those interpolated between the actual test data points for each residential site group at the frequency-of-events condition judged, on the average, to most closely approximate the real site noise exposure conditions (see Section 3.2 above). A small correction has also been applied to the field test data scores to correct for the varying noise exposure conditions at the various residential sites which the observers encounter during field noise judgements. This field variability is seen in the data of Tables 1 and 2. Each field response is adjusted assuming that the NEF value at the site where the response was generated is altered to equal the average NEF value for all the sites (in either group). This score adjustment is obtained by determining the slope of the average field site score when plotted against the calculated NEF exposures (Tables 1 and 2) for the sites, using the complete field response score data available for all residential sites in either group (see Fig. 8 and below).

The best linear fit of this score data is also plotted in each of these figures (7a and 7b), together with the usual correlation coefficient, r. It is seen that the correlation obtained for the Malton site is encouragingly large, and significant at the 1% level, however the corresponding correlation for the Oshawa observers is quite low showing in part a weak correlation between field and laboratory noise exposure conditions, and much less appropriate laboratory simulation.

In order to carry out the corrections for the field scores discussed above it is necessary to obtain a value for the rate of change of the averaged field score with the NEF site exposure values. This parameter was obtained by plotting the average subjective field score; see Figs. 8(a) and 8(b) (Question 2, McMaster study) for all field respondents, at a given site against the calculated site NEF exposure value. Sites adjacent to Malton and Oshawa airports were treated separately, and for the Malton sites two NEF values are available, a NEF value calculated by means of the FAA Integrated Noise Model program (see Ref. 10, also Ref. 8) and a NEF value calculated using Transport Canada program (see Ref. 11). For the Malton sites both NEF values have been plotted against the associated field scores, the best fit linear relationship for the INM data has been determined and the corresponding correlation coefficient calculated. It is seen that a substantially improved correlation is achieved for the data when the INM NEF values are used. These latter NEF values are generally, but not always, lower (by about 1 NEF value) than the NEF values calculated using the Transport Canada exposure procedure. For the Oshawa residential sites only the Transport Canada NEF values are shown together with the calculated best linear dependence and the associated correlation. The INM calculations are seen to give a significantly higher correlation for the Malton residential sites (and have been used in the score corrections outlined above). The NEFCAL correlation is actually negative and not significant for the Malton sites. For the Oshawa sites, on the other hand, the NEFCAL procedure yielded a satisfactory positive correlation and the associated NEFCAL slope has been used for the Oshawa sites.

An additional important comparison between the field and laboratory results can be made through a comparison of the variability of the observers' subjective scores in both situations. In the usual field testing method, a group of observers are interviewed at a given site experiencing as closely as possible identical aircraft noise exposures. This procedure is repeated at a

number of different noise exposure intensitics and sites, with a new group of observers at each constant, or nearly constant, field exposure level. Because of the usual exposure variability experienced at a given community site, this variability is superimposed on the person-to-person variability of the observers used. In laboratory studies the noise exposure is closely controlled for all observers, so that the person-to-person variability alone remains. This control is achieved at the expense of a potential loss of realism, and the possible loss of significant parallel annoyance inputs missing in the laboratory simulation.

In the present tests, the same observers participated in both types of noise judgements, so that the same person-to-person variability for both tests would be expected. Unfortunately, the laboratory observer group in the present tests were drawn from a range of residential sites (at both airports) having a rather significant variation in noise exposure. This latter variation must be removed before the true person-to-person variability can be identified in the field responses and compared to that obtained in the laboratory testing. Table 6, for the Malton observer group, compares the laboratory subjective score (numerical scale +8 to -8) results to the raw field subjective scores (numerical scores 1-9) and to the corrected field scores, correcting all field site NEF (INM) values to the same (averaged subjectively) common NEF value (NEF ~ 27.6). The exposure/score corrections are based on the sensitivity (slope) data shown in Fig. 8 for both groups of airport sites. For the Malton group of sites the following variability is noted.

	Sum of Score Deviations Squared
Laboratory scores* (20 observers)	9.8
Field scores (20 observers) 10 sites - raw data	28.6
Field scores (20 observers) corrected	17.5

*Converted to 1-9 Numerical Rating

For the Oshawa group, the corresponding variability is:

	Sum of Score Deviations Squared
Laboratory scores*	10.6
Field scores - uncorrected	75.5
Field scores - uncorrected (2 observers deleted)	(22.9)
Field scores - corrected	72.1
Field scores - corrected (2 observers deleted)	20.2

*Converted to 1-9 Numerical Scale

It is seen that the correction of the field scores to a common NEF exposure reduces the variability of the responses in both cases. Nevertheless the field variability is still somewhat larger than that obtained in the laboratory simulation testing and especially for the Oshawa observers must be attributed to either or both of the following factors:

(i) The simple NEF corrections applied do not adequately account for the field variability actually encountered.

(ii) Significant field inputs to the annoyance judgements are not adequately simulated in the laboratory listening environments.

The sensitivity of the observer groups to aircraft noise exposure changes, as measured by the laboratory and field measurements, may also be compared. From the plot of Fig. 8(a), using the INM calculated exposures, a field sensitivity from the best fitted linear representation of the field score data of $(\Delta_{SCORE}/\Delta_{NEF})_{FIELD} = 0.19$ is obtained for the Malton sites. This ratio is in terms of the change in the numerical subjective score rating (1-9 scale), per unit NEF exposure increase. In the laboratory Malton simulations, a change in the average subjective response of 3.8 units has been experimentally obtained over the total range of exposures used, which involved an event frequency increase by an eight-fold factor. The associated L_{eq} change was 5 dB, which includes the effect of a nearly constant background signal on all tapes between the actual aircraft noise events. If the experimental noise exposure were based exclusively on the aircraft events alone the corresponding NEF change would have been larger and would be 9 dB. Thus the laboratory sensitivity on a comparable basis to that shown above for the field tests is

$$\left(\frac{\Delta_{SCORE}}{\Delta_{NEF}}\right)_{LAB} = \frac{3.8/2^*}{9} = 0.21$$

(*This factor is required to account for the differences in the numerical range used in the two test scales to account for identical subjective changes.)

It is seen that the sensitivities to noise exposure changes, as measured by the two test procedures for the Malton observers, is in good agreement provided the field sensitivity is based on the INM Noise Exposure calculations. Unfortunately there is a considerable change in the field sensitivities of the NEF when calculations are based on the existing Transport Canada model, so that in this case agreement with the laboratory exposure sensitivity cannot be shown.

For the Oshawa observers, the parallel sensitivity calculations based on the NEF Transport Canada model for the field noise exposures, shows a considerable variation between laboratory and field noise exposure sensitivities, with the laboratory results showing a considerably greater sensitivity to noise exposure changes. Since the laboratory listening conditions do not model a major annoyance feature of the Oshawa residential sites (i.e., indoor-relaxation and sleep interference), this result is not unexpected. However in comparing the field noise data only at the two airport sites and using the Transport Canada noise exposure model at both sites, it is surprising to note the large indicated change in noise exposure sensitivity at the two airport sites.

4.0 CONCLUSIONS

The following are the major results and conclusions arising from the present subjective laboratory studies with simulated aircraft noise exposures.

(1) For a given laboratory simulation of residential outdoor noise adjacent to an airport site, the 30 minute average subjective evaluations of the aircraft noise exposure were almost identical for both groups of test observers. It does not therefore appear that any biasing or preconditioning influenced the laboratory assessments of noise.

(2) Carefully planned and executed laboratory simulation testing for the subjective response of typical residential aircraft noise exposures near airports can yield a high degree of correlation with conventional field-interview annoyance data. In the present testing a correlation coefficient of $r = 0.56$, significant at the 1% level, was obtained for the field and laboratory responses of the same set of test observers.

It is suspected that a higher degree of correlation would be demonstrated for a set of observers having a more uniform field noise exposure than was possible for the present study.

(3) Although the character of the aircraft noise presented in the laboratory simulations carefully reproduced the actual residential noise exposures of the test observers at both airport sites, the simulation was significantly more successful for the Malton observers than it was for the Oshawa observers. A major annoyance associated with Malton noise exposure as reported by the test observers is associated with conversation or speech interference outdoors, a condition closely simulated in the laboratory sessions. A major annoyance factor associated with the Oshawa aircraft noise exposure is sleep or relaxation interference indoors, a condition not closely simulated.

(4) The test observers have defined the number of aircraft events as typical of their own residential noise exposure as being close to the expected peak hour frequency occurring at their home residences. For the Malton observers, for whom the simulation was most successful, this number was in fact in excess of the peak hour flying event frequency.

(5) The character of the aircraft noise exposure experienced at residential sites adjacent to the airports studied in these tests is significantly different. At equal L_{eq} values the noise exposures adjacent to the larger international airport contain recurring peak levels considerably higher (10 dB) than the peak levels characterizing the general aviation airport. In addition the former noise exposure at equal values of L_{eq} contains many periods of extended quiet between aircraft events not present in general aviation noise exposures. As a result, the total 30 minute noise exposures characterizing the larger international airport exposures were consistently judged (by both observer groups) as substantially less disturbing/annoying at equal L_{eq} values.

(6) At the defined optimum simulation conditions, both sets of observers consistently rate the international airport noise exposure as considerably and distinctly more disturbing and annoying than that characterizing

the general aviation airport sites. Only a relatively small fraction of this annoyance differential can be explained by the long term (30 day) averaged NEF exposures at the sites adjacent to the two airports ($\Delta_{NEF} \approx 3.0$). An improved laboratory simulation of the general aviation airport noise exposure – using an indoor test simulation procedure – would be expected to increase the annoyance parameters measured for these sites, thus reducing or eliminating the presently measured large subjective response differential.

(7) The combined subjective responses from the half hour laboratory evaluations, including both types of airport noise exposures, shows excellent correlation ($r = 0.97$) against the time-above-variable $(TA)_{85}$ (duration that aircraft signal exceeds 85 dB, linear). Conversely, the subjective response, including both airport noise exposures shows very poor correlation against the physical L_{eq} variable.

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FIELD RESULTS - MALTON

AT

RESIDENCES OF LABORATORY OBSERVERS

(McMASTER STUDY - REF. 8)

SITE DESIGNATION	LABORATORY OBSERVERS	SITE N.E.F. (NEFCAL)	SITE N.E.F. (I.N.M.)	AVERAGE ANNOYANCE SCORE (QUESTION 2b)	STANDARD DEVIATION OF SCORE
3026	2	28.7	25.4	7.38	1.31
3041	2	33.1	32.0	8.29	1.64
3046	3	26.9	30.1	7.47	2.00
3050	3	27.6	27.1	8.27	0.31
3055	2	26.7	29.2	7.82	1.40
3089	2	28.4	27.4	6.64	1.63
7069	2	27.9	25.7	5.83	1.03
7080	1	27.7	26.2	7.22	1.09
7289	2	26.9	25.9	7.83	1.26
7399 (AVGE)	1	30.8 (28.5)	27.4 (27.6)	6.17	1.47

TABLE 1

FIELD RESULTS - OSHAWA

AT

RESIDENCES OF LABORATORY OBSERVERS

(McMASTER STUDY - REF. 8)

SITE DESIGNATION	LABORATORY OBSERVERS	SITE N.E.F. (NEFCAL)	SITE N.E.F. (I.N.M.)	AVERAGE ANNOYANCE SCORE (QUESTION 2b)	STANDARD DEVIATION OF SCORE
55-4	6	23.2		6.08	2.31
55-1	4	25.0		6.17	1.90
50-9	2	25.8		6.83	1.19
50-4	1	27.2		6.39	2.26
50-3	3	30.2		7.00	1.35
50-2	1	24.0		6.29	2.23
50-1 (AVGE)	3	25.4 (25.8)		6.23	1.83

TABLE 2

TEST OBSERVERS - MALTON

RESIDENTIAL NOISE - WHERE/WHEN/HOW DISTURBED

(REFERENCE 8)

OBS. NO.	INDOOR		OUTDOOR		NIGHT	GENERAL	NOISE INTERRUPTS	NOISE EFFECTS
	DAY	EVE	DAY	EVE				
1	7	8	10	9	9	9		Sleep/Awake
2	5	10	7	10	10	10	Relax,Conv.Tel (in) (in/out)	Hard Hearing Irrit.Health
3	8	8	10	10	0	5	Conver. (in/out)	Irritable
4	7	8	9	9	2	7	Conver.Tel (in/out)	Irritable
5	5	7	10	10	0	10	Sleep,Conv.	Nervous Irrit.Sleep
6	6	6	10	10	0	10	Conv. (in/out)	
7	8	6	10	9	3	6	Conv. (in/out)	
8	8	8	10	10	9	9	Conv.(out)	
9	7	7	9	9	5	6	Conv.(out)	
10	6	6	6	6	1	6	Conv.(in)T.V. Tel.	Interrupts Sleep
11	8	7	10	9	9	7	Conv.(out)	
12	3	3	4	7	0	5	Conv.(out)	
13	0	0	0	0	0	0	Conv.(in/out) T.V., Tel.	
14	3	2	5	3	1	3		
15	5	6	8	9	1	7		Irritable Headache
16	0	0	0	0	0	0		
17	7	3	10	9	0	8	Conv.(in/out) Tel.	
18	5	5	9	9	1	7	Conv.(in) T.V., Tel.	
19	0	5	7	6	0	2	Conv. (in)	
20	5	6	7	8	1	4	Conv.(out) Sleep, Relax	Keeps Awake
21	6	6	9	9	1	4	T.V.	Sleep Interf.
AVGE	5.2	5.6	7.6	7.6	2.5	6.0	Speech or Conv.Inter. 81%	Sleep Interf. 29%

TABLE 3

TEST OBSERVERS - OSHAWA

RESIDENTIAL NOISE - WHERE/WHEN/HOW DISTURBED

(REFERENCE 8)

OBS NO	INDOORS		OUTDOORS		NIGHT	GENERAL	NOISE INTERRUPTS	NOISE EFFECTS
	DAY	EVE	DAY	EVE				
1	0	0	0	8	0	0	Relax Conver.(in/out)	Nerves
2	6	6	9	9	9	7		Irritability Sleep
3	0	0	0	0	9	5	Sleep	Sleep Irritability
4	5	7	7	9	9	6	Sleep, Tel. Conver.(out)	Sleep
5	1	1	6	4	2	3	Relax(out)	Sleep
6	6	3	6	3	0	3	Sleep	
7	0	0	4	9	6	4	Sleep	
8							Conver.(out)	
9							Work (in)	
10	3	6	6	6	8	7	Sleep	
11	0	0	1	1	2	0	Sleep	
12								
13	3	3	6	3	1	3		
14	4	4	5	5	5	4		
15	0	2	0	2	5	1		
16								
17								
18	0	0	0	0	10	0		Sleep
19	7	2	7	4	5	7	Sleep	Irritable
20	0	0	1	0	5	1	Sleep	Sleep
21								
22	6	8	8	8	6	8	Relax(in/out) Conv. (out)	Irritability Sleep Keep awake
AVGE	2.5	2.5	4.1	4.4	5.1	3.7	Speech Interference 16%	Sleep Disturb. 43%

TABLE 4

SENSITIVITY DISTRIBUTIONS

(PERCENTAGES OF OBSERVERS)

	GENERAL NOISE SENSITIVITY RATING				
	1	2	3	4	5
LABORATORY OBSERVERS MALTON GROUP	0	30	65	5	0
FIELD RESPONDENTS MALTON - McMASTER STUDY	12	23	46	15	4
LABORATORY OBSERVERS OSHAWA GROUP	5	15	55	15	10
FIELD RESPONDENTS OSHAWA - McMASTER STUDY	13	20	48	16	3

TABLE 5

LABORATORY OBSERVERS - MALTON

SUBJECTIVE RESPONSES
FIELD DATA/SIMULATION DATA

OBSERVER No.	FIELD SITE	NEGATIVE OF LAB SCORE	FIELD SCORE (A/C INTENSITY)	SITE NEF (INM)	ADJUSTED FIELD SCORE
1	3-41	8	9	33.1	8.6
2	3-41	8	9	33.1	8.6
3	3-50	5	7	27.6	7.3
4	3-50	5.5	7	27.6	7.4
5	3-50	6	9	27.6	9.3
6	3-55	5	9	26.7	9.0
7	3-55	4.5	8	26.7	8.0
8	7-289	7	9	26.9	9.3
9	7-289	6	8	26.9	8.3
10	3-26	5	8	28.7	8.0
11	3-26	7	9	28.7	9.0
12	3-89	5	7	28.4	7.2
14	7-69	3	6	30.8	5.8
15	7-399	5	8	27.9	8.1
17	3-55	7	9	26.7	9.5
18	3-46	6	9	26.9	9.3
19	3-46	8	8	26.9	8.5
20	7-69	6	6	27.9	6.8
21	7-80	8	7	27.1	7.8

TABLE 6(a)

LABORATORY OBSERVERS - OSHAWA

SUBJECTIVE RESPONSES
FIELD DATA/SIMULATION DATA

OBSERVER NO.	FIELD SITE	NEGATIVE OF LAB SCORE	FIELD SCORE (A/C INTENSITY)	SITE NEF (NEFCAL)	ADJUSTED FIELD SCORE
1	55-4	7	6	23.2	6.2^5
2	55-4	7	9	23.2	9.2^5
3	55-4	5	8	23.2	8.2^5
4	55-1	4	7	25.0	7.1
5	50-3	5	6	30.2	5.4
6	50-3	5	7	30.2	6.4
7	50-9	6	8	25.8	7.9
8	50-1	6	1	25.4	1.0
10	55-4	1	7	23.2	7.2^5
11	50-1	4	6	25.4	6.0
12	50-4	3	2	27.2	2.2
13	55-1	7	7	25.0	7.1
14	55-4	4	4	23.2	4.3
15	50-2	5	7	24.0	7.2
19	50-1	6	7	25.4	7.0
20	55-1	7	6	25.0	6.1
22	50-3	6	9	30.2	8.4

TABLE 6(b)

LABORATORY NOISE EXPOSURES

SESSION	NUMBER OF AIRCRAFT EVENTS	30 MINUTE LEQ (LINEAR)	$10 \log_{10}(TA)_{85}$	$10 \log_{10}(TA)_{80}$
MD1	32	93.0	26.0	27.3
MD2	16	91.1	24.5	25.8
MD3	8	90.0	21.5	22.7
MD4	4	88.0	19.7	21.0
OD1	48	85.6	22.6	25.6
OD2	24	82.5	18.5	21.5
OD3	12	80.0	17.0	20.0
OD4	6	77.4	14.6	17.6

TABLE 7

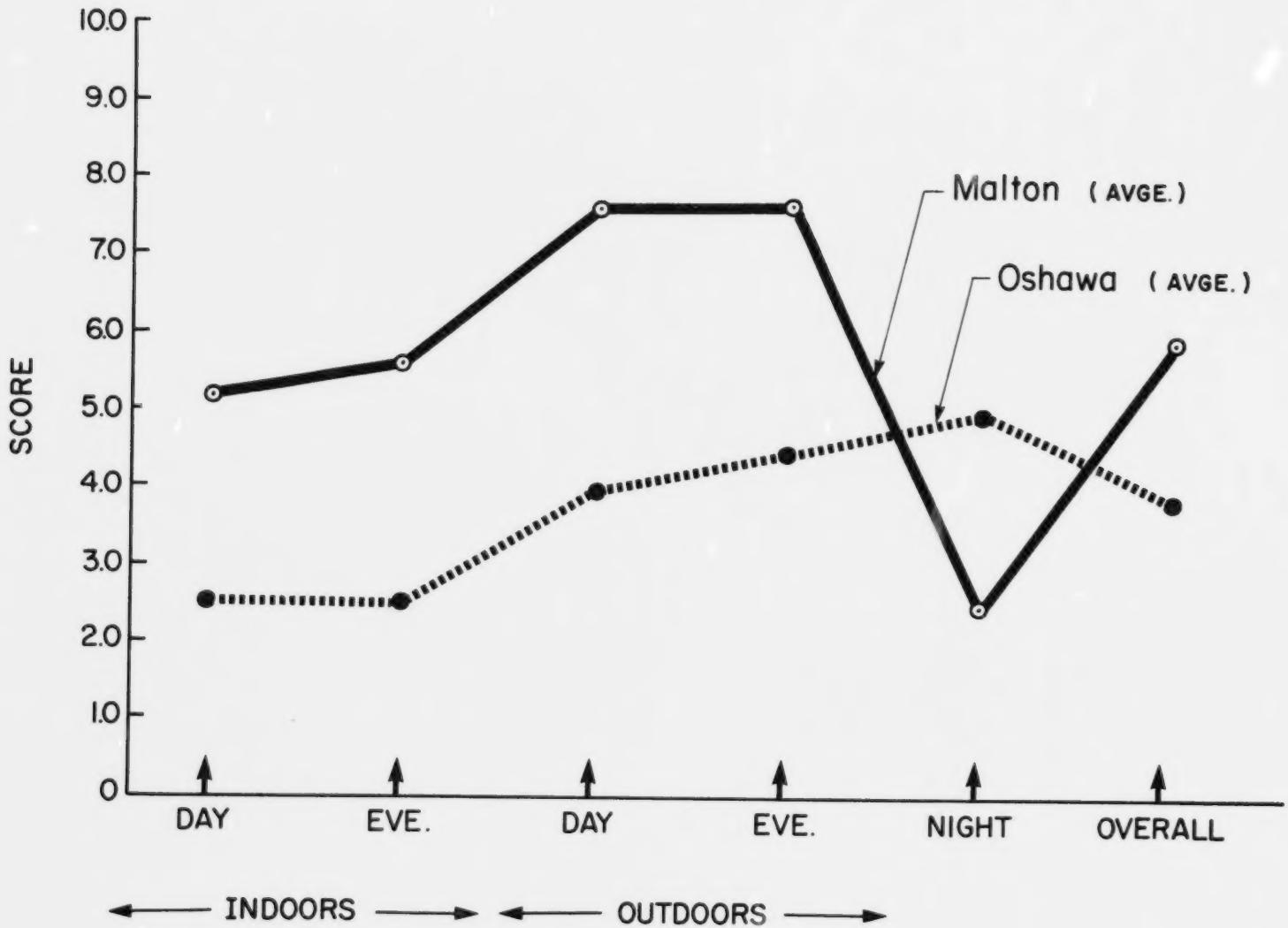

Fig. 1 AIRCRAFT RESIDENTIAL ANNOYANCE

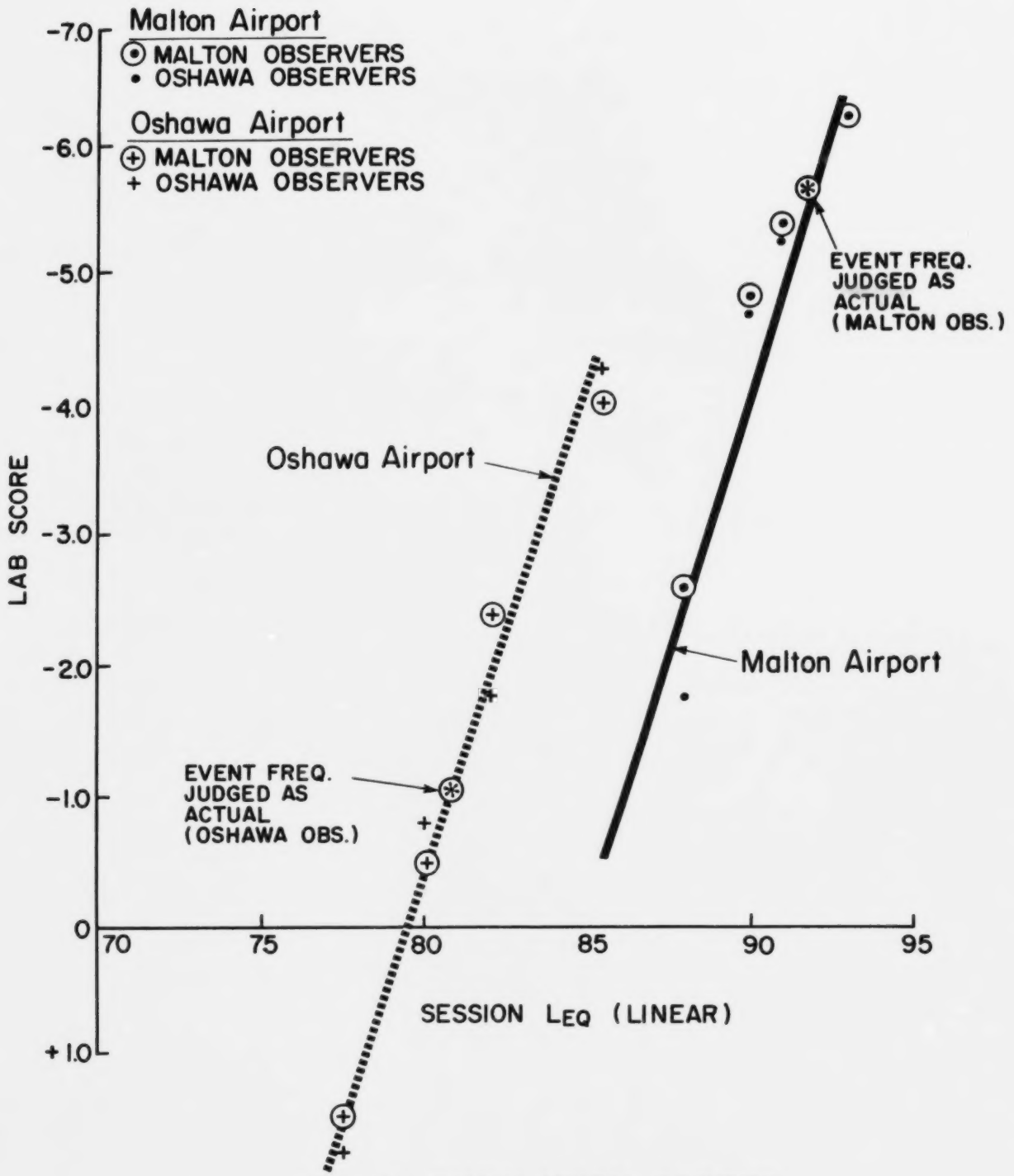

Fig. 2 SIMULATION SCORES

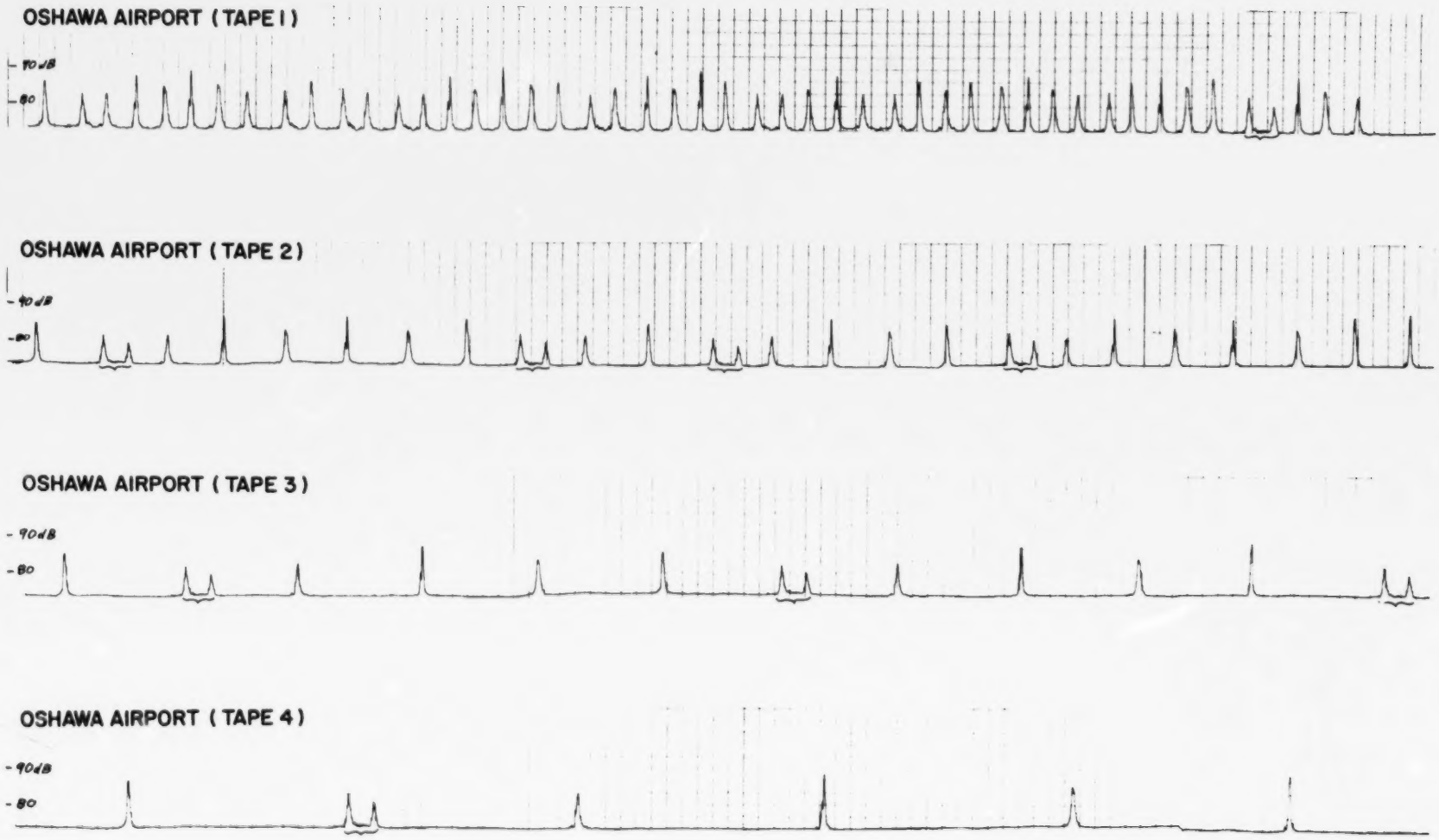

FIG. 3(a) OSHAWA AIRPORT MASTER TAPES

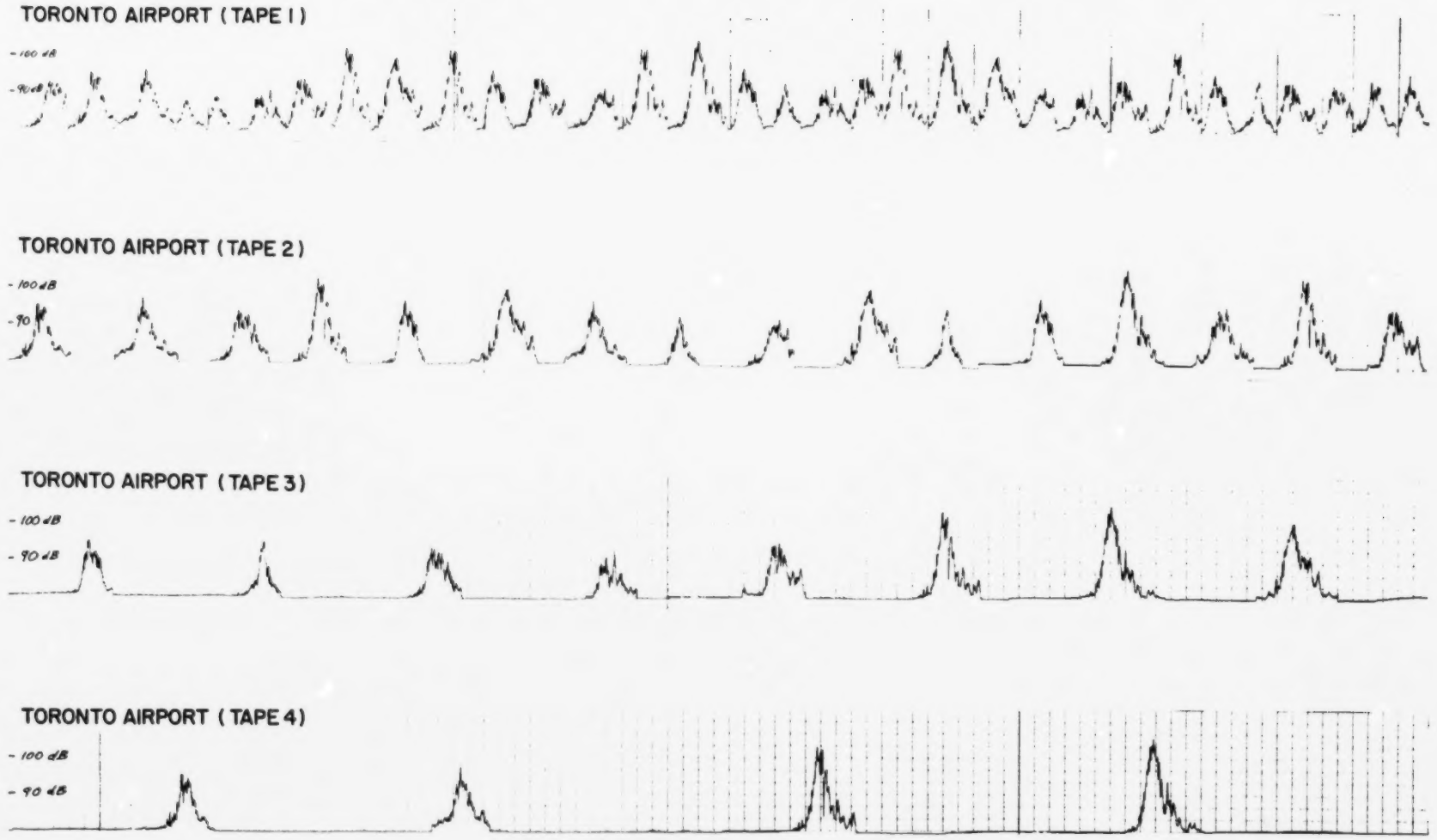

FIG. 3(b) TORONTO AIRPORT MASTER TAPES

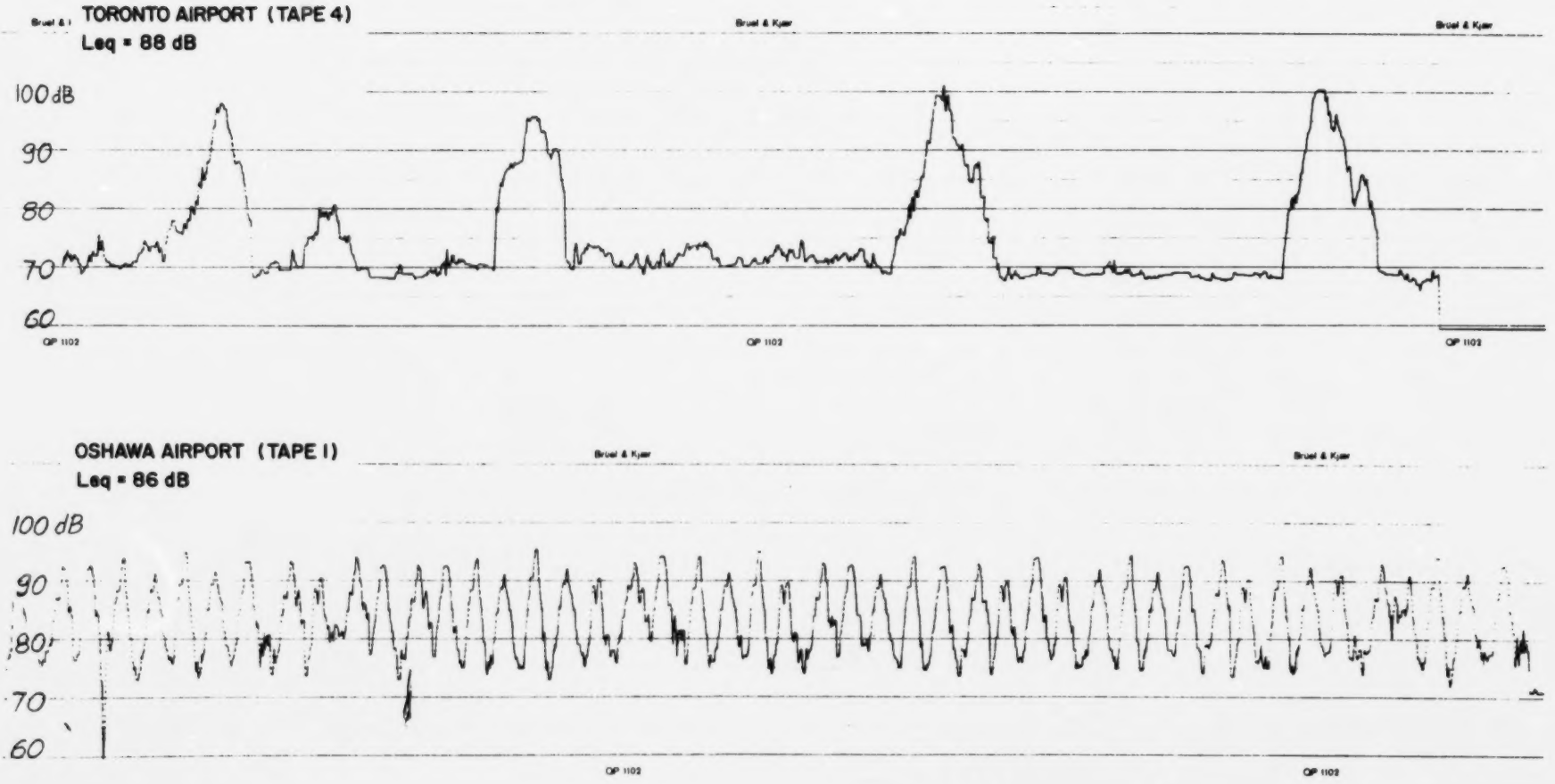

FIG. 3(c) TYPICAL NOISE RECORDINGS DURING JURY LISTENING TEST SESSIONS

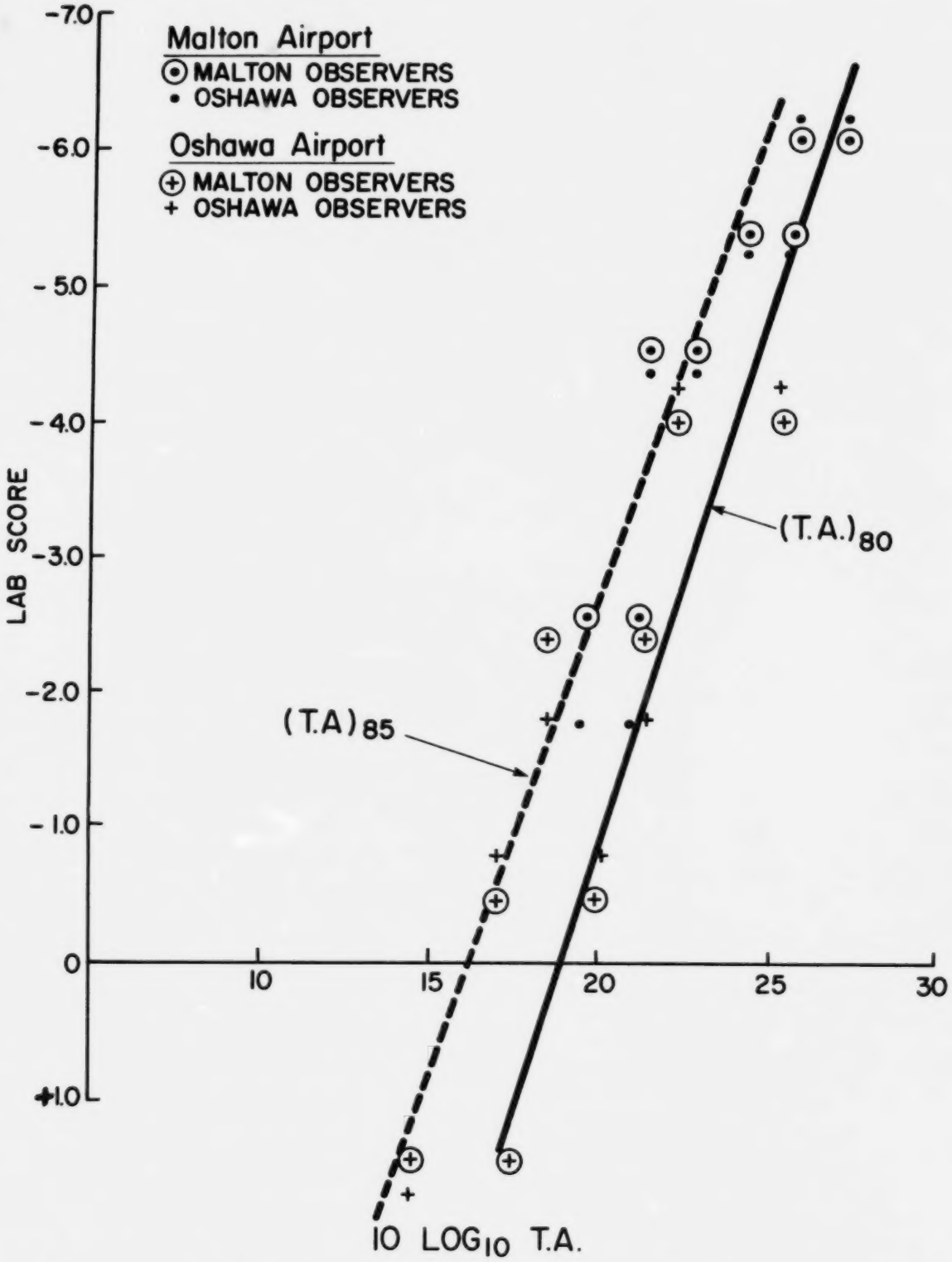

Fig. 4 VARIATION OF LABORATORY SIMULATION SCORES WITH 10 LOG_{10} (TA)

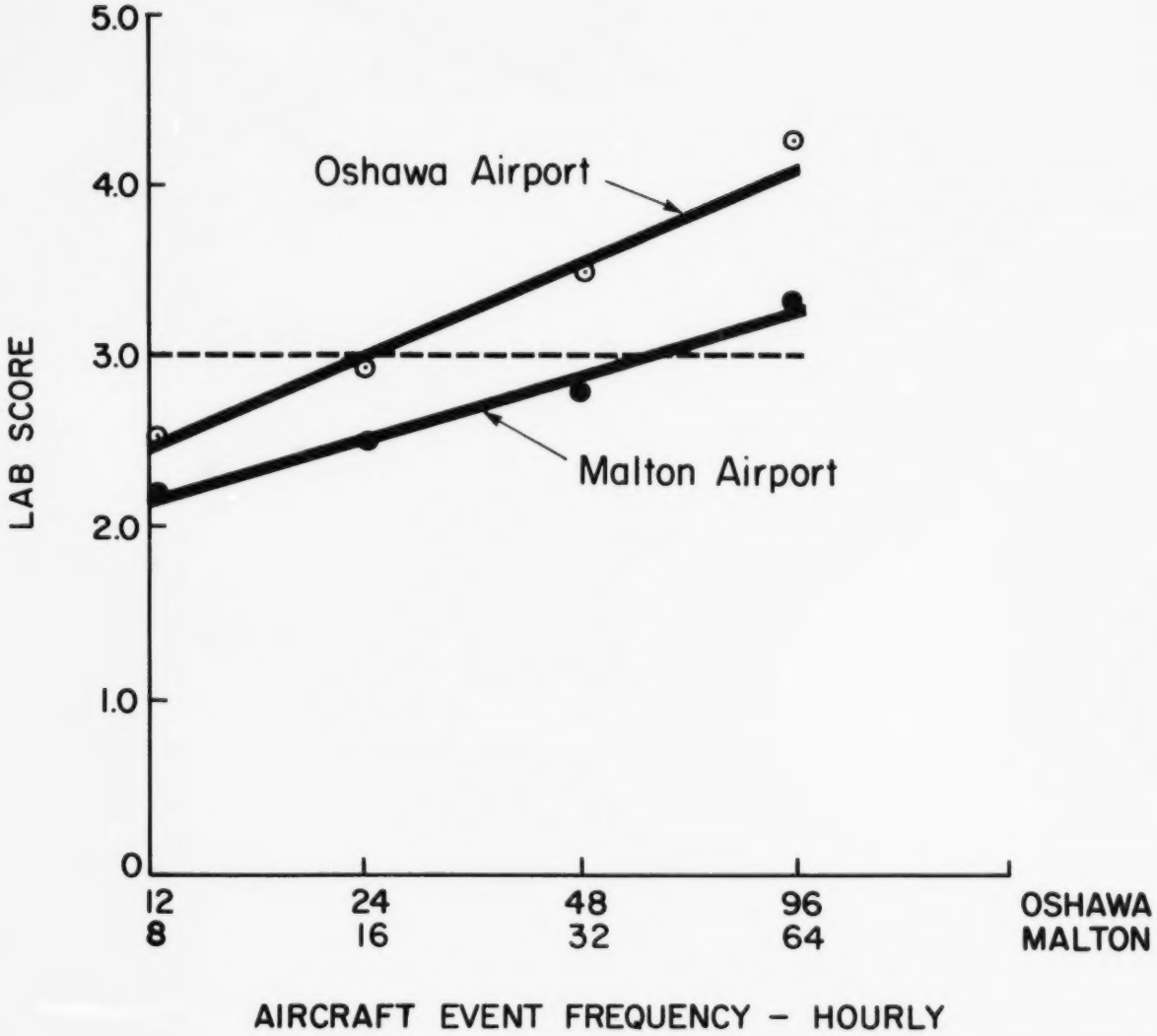

Fig. 5 FREQUENCY OF EVENTS SCORE

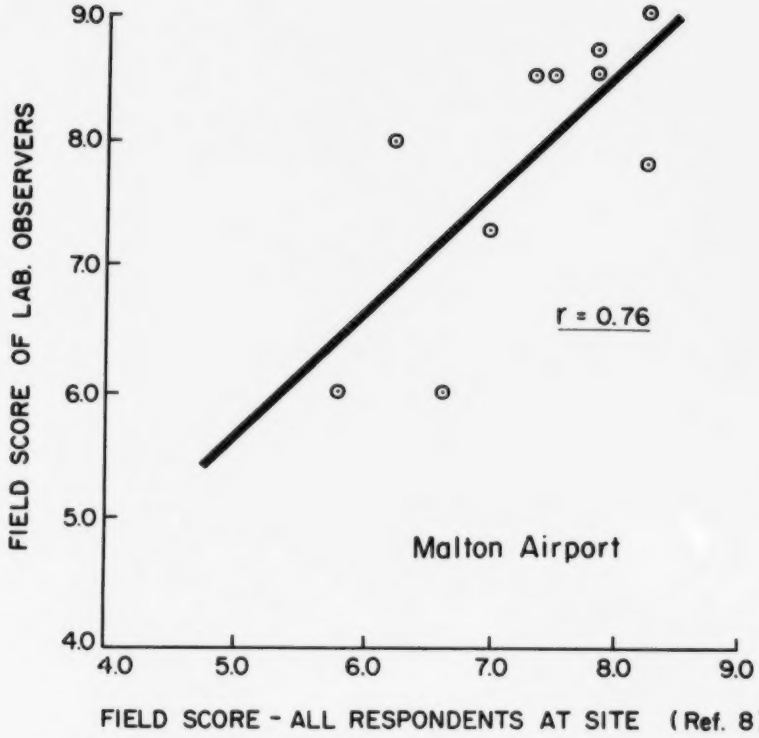

Fig. 6(a) FIELD RESPONSE - MALTON OBSERVERS

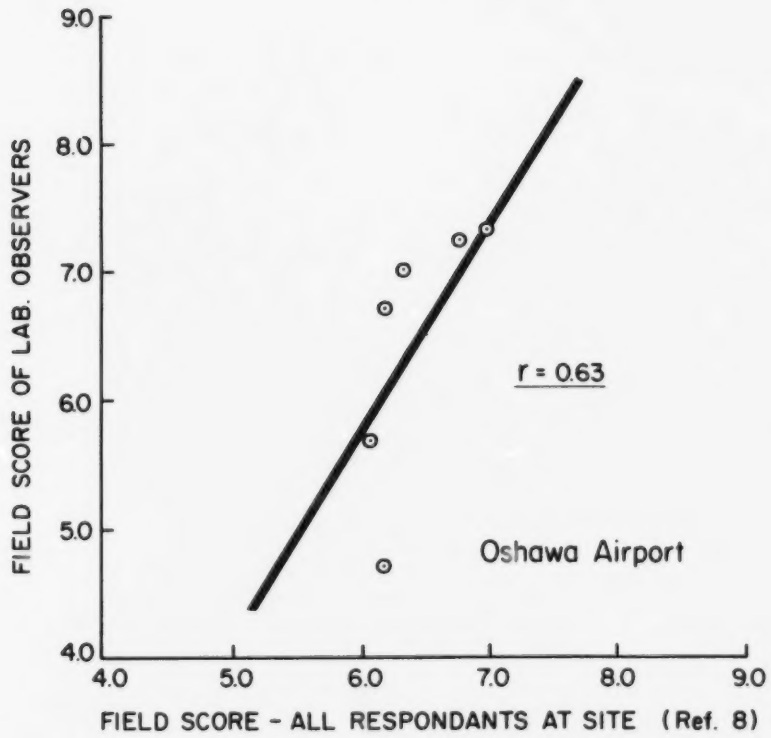

Fig. 6(b) FIELD RESPONSE - OSHAWA OBSERVERS

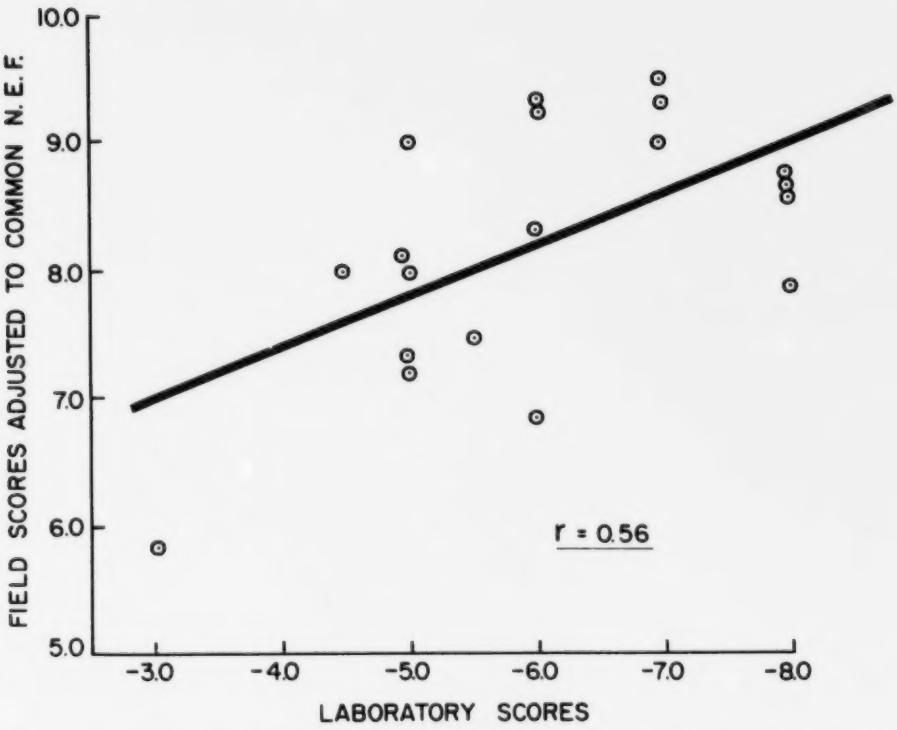

Fig. 7(a) LAB/FIELD RESPONSE CORRELATION
MALTON AIRPORT

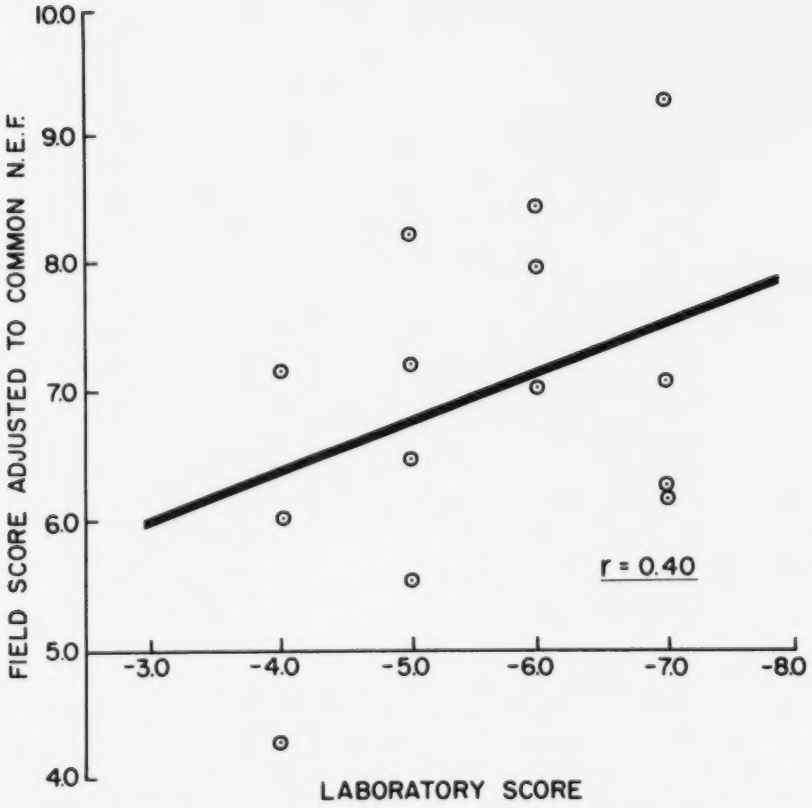

Fig. 7(b) LAB/FIELD RESPONSE CORRELATION
OSHAWA AIRPORT

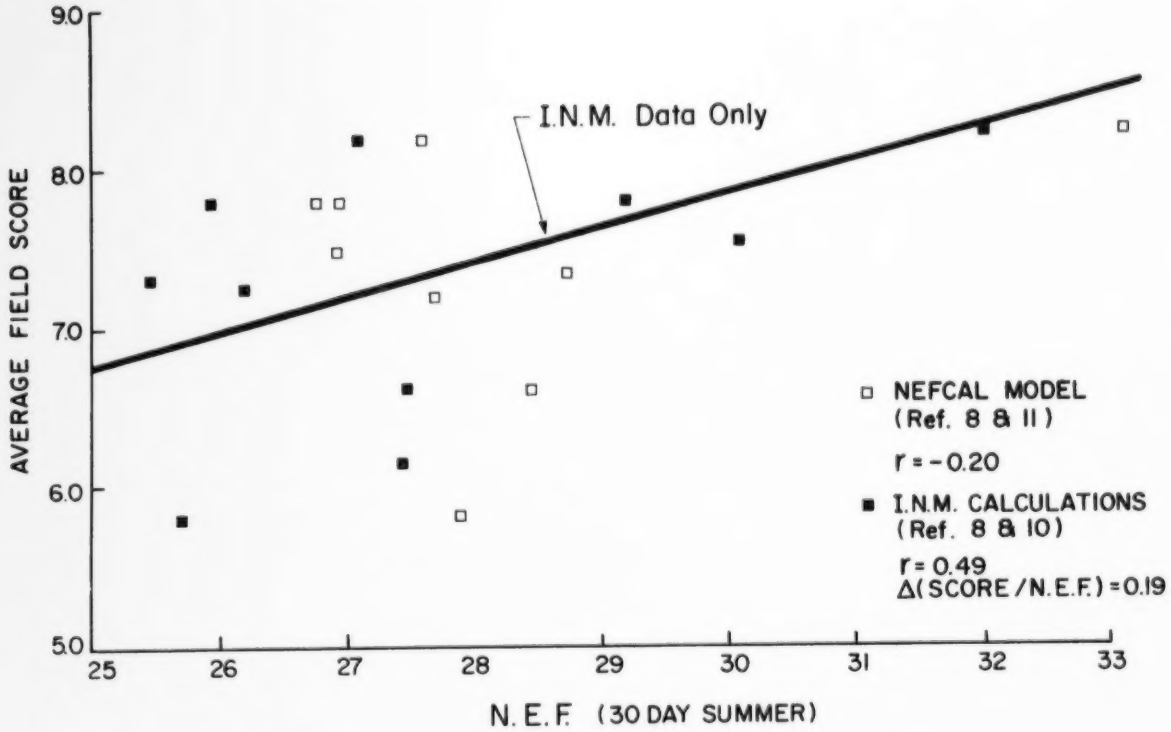

Fig. 8(a) FIELD ANNOYANCE VARIATION WITH N.E.F. MALTON AIRPORT

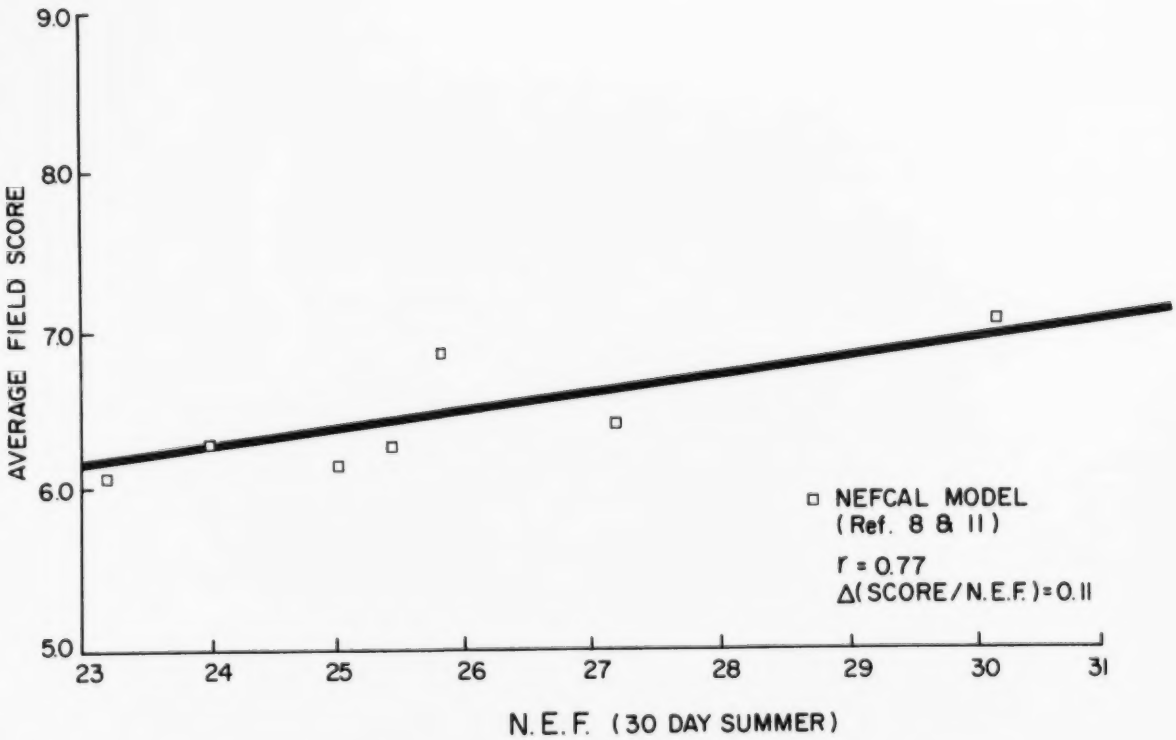

Fig. 8(b) FIELD ANNOYANCE VARIATION WITH N.E.F. OSHAWA AIRPORT

UNIVERSITY OF TORONTO AIRCRAFT NOISE STUDY

1. What are the dominating noise sources at your home environment? Indicate your rating of the sources below with (1) for the most dominant; (2) for the next most dominant, etc., and N/A for sources which are not applicable.

Main highways	☐
Local traffic	☐
Aircraft	☐
Trains	☐
Industrial	☐
Other (specify)	☐

Name _____ Date _____

2. (a) Your awareness of aircraft noise in your home environment <u>during the summer months</u> is primarily experienced:

- Indoors ☐
- Outdoors ☐
- Both indoors and outdoors ☐

(b) During the summer months, what activities are you involved in when you hear aircraft overflights (check several if appropriate):

Sleeping	☐	T.V. inside	☐
Relaxing inside	☐	T.V. outside	☐
Relaxing outside	☐	Telephone conversation inside	☐
Conversing inside	☐	Telephone conversation outside	☐
Conversing outside	☐	Eating inside	☐
Working inside	☐	Eating outside	☐
Working outside	☐		

3. (a) Your awareness of aircraft noise in your home environment <u>during the remaining months of the year</u> is primarily experienced:

- Indoors ☐
- Outdoors ☐
- Both indoors and outdoors ☐

(b) During the remaining months of the year, what activities are you involved in when you hear aircraft overflights (check several if appropriate):

Sleeping	☐	T.V. inside	☐
Relaxing inside	☐	T.V. outside	☐
Relaxing outside	☐	Telephone conversation inside	☐
Conversing inside	☐	Telephone conversation outside	☐
Conversing outside	☐	Eating inside	☐
Working inside	☐	Eating outside	☐
Working outside	☐		

UNIVERSITY OF TORONTO

AIRCRAFT NOISE STUDY

NAME _____ DATE _____

SESSION NO. _____ TAPE NO. _____

1. If the simulated outdoor airplane flyover events you have just experienced were present in your home environment, would you rate their effect as:

(i) ☐ Agreeable - Go to 2

(ii) ☐ Disturbing - Go to 3

(iii) ☐ Neutral (neither of the above two)

2. If your answer to (1) was (i), please rate your judgement of the noise exposure on a scale from 1 to 8 as below (circle appropriate number):

Slightly agreeable		Moderately agreeable		Considerably agreeable		Extremely agreeable	
1	2	3	4	5	6	7	8

3. If your answer to (1) was (ii), please rate your judgement of the noise exposure on a scale from 1 to 8 as below (circle appropriate number):

Slightly disturbing		Moderately disturbing		Considerably disturbing		Extremely disturbing	
1	2	3	4	5	6	7	8

4. Comparing the simulated airplane flyover events you have just experienced, we would like you to estimate how this relates to the actual exposures that you recall as typical of those at your own residence:

	Number of airplanes during session	Average loudness of airplanes just heard
Considerably in excess of residence	☐	☐
In excess of residence	☐	☐
Similar to residence	☐	☐
Less than residence	☐	☐
Considerably less than residence	☐	☐

SAMPLE CELL _____ (1-2)

BLOCK CODE _____ (3-5)

ADDRESS _____ (6-9)

INTERVIEWER # _____ (1/10)

START TIME _____ (1/11-14)

NEIGHBOURHOOD ATTITUDE SURVEY

McMASTER UNIVERSITY

TRANSPORTATION RESEARCH GROUP

CALL	DATE	TIME	RESPONSE
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____

INTRODUCTION: Hello, I'm from the Geography Department at McMaster University in Hamilton. I'm interviewing people to find out their opinions about their neighbourhood. Could you spare me about 10 minutes? Thanks very much.

1a. What are the important things you like about living in this neighbourhood?

[✓ *all items mentioned in column "Like V"*]

b. What the important things you don't like about living in this neighbourhood?

[✓ *all items mentioned in column "Don't like V"*]

c. [*Use CARD A*]

Here are some other things that have been mentioned. Are any of them important to you as things you like or don't like about this neighbourhood?

[✓ *all items mentioned in column "Like E" or "Don't like E"*]

Item	Like V (1)	Like E (2)	Don't Like V (3)	Don't Like E (4)	
Schools	___	___	___	___	
Shopping	___	___	___	___	
Open Space	___	___	___	___	
Recreational Facs.	___	___	___	___	
Bus Service	___	___	___	___	
Proximity to Work	___	___	___	___	
Noise	___	___	___	___	(1/15)
Quietness	___	___	___	___	(1/16)
Air Quality	___	___	___	___	
Landscaping	___	___	___	___	
Cost of Housing	___	___	___	___	
Quality of Housing	___	___	___	___	
Neighbours	___	___	___	___	
Safety for Children	___	___	___	___	
Crime	___	___	___	___	
Maintenance	___	___	___	___	
Privacy	___	___	___	___	
Parking	___	___	___	___	
Other (specify)	___	___	___	___	

d. [*Use CARD B*]

In general, how satisfied are you with this neighbourhood as a place to live.

(1) extremely satisfied	___	(6) slightly dissatisfied	___	(1/17)
(2) considerably satisfied	___	(7) moderately dissatisfied	___	
(3) moderately satisfied	___	(8) considerably dissatisfied	___	
(4) slightly satisfied	___	(9) extremely dissatisfied	___	
(5) neutral	___			

e. If you could change just one thing about this neighbourhood, what would it be?

_____ (1/18)

[You have mentioned quietness/noise; I'd like to ask you more about that.]

OR

[One of the things we're particularly interested in is the sounds people notice and I'd like to ask you about that.]

2a. What sounds do you notice when you are at home?

[✓ *all sources mentioned in column V*]

[*If road traffic noise is volunteered, ask whether main road or local*]

b. [*Use CARD C*]

How do you rate each of the sounds you have mentioned?

[*Enter EA-ED rating in column INTENS.*]

1 = Extremely Agreeable	6 = Slightly Disturbing
2 = Considerably Agreeable	7 = Moderately Disturbing
3 = Moderately Agreeable	8 = Considerably Disturbing
4 = Slightly Agreeable	9 = Extremely Disturbing
5 = Neutral	

c. [*Use CARD D*]

Here is a list of common sounds (you have already mentioned some). Do you ever notice any of these (any of the others)?

[✓ *all sources mentioned in column E*]

d. [*Use CARD C*]

How do you rate each of those additional sounds you have mentioned?

[*Enter EA-ED rating in column INTENS.*]

e. Considering all you have mentioned, how would you rate the overall noise?

[*Enter EA-ED rating in column INTENS.*]

4

Source	V (1)	E (2)	Intens. (EA-ED)	
Children/other people	___	___	___	
Handyman tools	___	___	___	
Air conditioner	___	___	___	
Domestic pets	___	___	___	
Garden machinery	___	___	___	
TV/radio/records	___	___	___	
Musical instruments	___	___	___	
Local traffic noise	___	___	___	(4/10-11)
Main road traffic noise	___	___	___	
Motorcycles	___	___	___	(5/10-11)
Trucks	___	___	___	
Snowmobiles	___	___	___	
Mini-bikes	___	___	___	(6/10-11)
Trains	___	___	___	(3/10-11)
Aircraft	___	___	___	(7/10-11)
Industrial noise	___	___	___	
Construction noise	___	___	___	
Institutional noise	___	___	___	
Mechanical or plumbing noise	___	___	___	
Other (specify)	___	___	___	
NEIGHBOURHOOD			___	(1/19)

[I would like to ask you more about your reactions to (aircraft/main road/ truck/train/industrial) noise and the overall neighbourhood noise]

3. [*Use CARD E*]

a. On this scale from 0 (not at all disturbed) to 10 (unbearably disturbed) how do you rate (source) noise and the overall neighbourhood noise:

[*Enter 0 to 10 rating in relevant source columns*]

	AIRCRAFT	MAIN ROAD	TRUCKS	TRAINS	INDUSTRY	NEIGHBOURHOOD
indoors day	___	___	___	___	___	___
outdoors day	___	___	___	___	___	___
indoors evening	___	___	___	___	___	___
outdoors evening	___	___	___	___	___	___
night	___	___	___	___	___	___
in general	___	___	___	___	___	___
	(3/12-29)	(4/12-29)	(5/12-29)	(6/12-29)	(7/12-29)	(1/20-37)

b. [*Ask only at Malton*]

On the same scale how do you rate (source) noise and the overall neighbourhood noise when:

[*Enter 0 to 10 ratings in relevant source columns*]

	MAIN ROAD	TRUCKS	TRAINS	INDUSTRY	NEIGHBOURHOOD
flight path in this direction	___	___	___	___	___
flight path not in this direction	___	___	___	___	___
	(4/30-35)	(5/30-35)	(6/30-35)	(7/30-35)	(1/38-43)

[*Omit Q's 4, 5, 9, 10 for sources with all zero ratings in 3a. and 3b.*]

4. [*For each disturbing source only*]

How often does (source) noise disturb you?

[*Read Categories*]

	AIRCRAFT	MAIN ROAD	TRUCKS	TRAINS	INDUSTRY
(1) less than once a day	___	___	___	___	___
(2) once or twice a day	___	___	___	___	___
(3) several times a day	___	___	___	___	___
(4) almost continuously	___	___	___	___	___
	(3/30)	(4/36)	(5/36)	(6/36)	(7/36)

5. [*For each disturbing source only*]

a. What time of year are you disturbed most by (source) noise?

	AIRCRAFT	MAIN ROAD	TRUCKS	TRAINS	INDUSTRY
(1) Summer	___	___	___	___	___
(2) Winter	___	___	___	___	___
(3) No difference	___	___	___	___	___
	(3/31)	(4/37)	(5/37)	(6/37)	(7/37)

b. What days and times are you disturbed most by (aircraft and/or "other source" noise)?

	AIRCRAFT	MAIN ROAD	TRUCKS	TRAINS	INDUSTRY
Days/times	___	___	___	___	___
No difference	___	___	___	___	___
	(3/32-33)	(4/38-39)	(5/38-39)	(6/38-39)	(7/38-39)

c. [*Use CARD E*]

How disturbed are you by (source) noise at this/these times?

	AIRCRAFT	MAIN ROAD	TRUCKS	TRAINS	INDUSTRY
Rating					

(3/34-36)(4/40-42)(5/40-42)(6/40-42)(7/40-42)

6. [*For all major sources noticed (Q's 2a/2c)*]

Are there any activities which (source) noise interrupts?

[*Volunteered answers only*]

Source	AIRCRAFT	MAIN ROAD	TRUCKS	TRAINS	INDUSTRY
Sleeping					
Relaxing in					
Relaxing out					
Conversing in					
Conversing out					
Working in					
Working out					
T.V.					
Telephone conversation					
Eating					

(3/37-46)(4/43-52)(5/43-52)(6/43-52)(7/43-52)

7. [*For all major sources noticed (Q's 2a/2c)*]

What effects on you and your family has (source) noise had?

[*Read list*]

	AIRCRAFT	MAIN ROAD	TRUCKS	TRAINS	INDUSTRY
Nervousness					
Hearing loss					
Irritability					
Headaches					
Interrupt sleep					
Kept awake					

(3/47-52)(4/53-58)(5/53-58)(6/53-58)(7/53-58)

8. [*For all major sources noticed (Q's 2a/2c)*]

Are there any effects of (source) noise that haven't been mentioned which concern you?

[*Write in as specified*]

AIRCRAFT	MAIN ROAD	TRUCKS	TRAINS	INDUSTRY
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
(3/53-54)	(4/59-60)	(5/59-60)	(6/59-60)	(7/59-60)

9. [*For each disturbing source only*]

When you are disturbed by (source) noise do you:

[*Read list*]

	AIRCRAFT	MAIN ROAD	TRUCKS	TRAINS	INDUSTRY
Close your window	___	___	___	___	___
Use air conditioning	___	___	___	___	___
Stay indoors	___	___	___	___	___
Turn on/up TV/radio/records	___	___	___	___	___
Wear earplugs	___	___	___	___	___
Contact noise source	___	___	___	___	___
Wait for noise to stop	___	___	___	___	___
	(3/55-61)	(4/61-67)	(5/61-67)	(6/61-67)	(7/61-67)

10. [*For each disturbing source only*]

Have you ever taken any of these actions in response to (source) noise?

[*Read list*]

	AIRCRAFT	MAIN ROAD	TRUCKS	TRAINS	INDUSTRY
Written to newspaper	___	___	___	___	___
Contacted noise source	___	___	___	___	___
Contacted police	___	___	___	___	___
Contacted politician	___	___	___	___	___
Contacted other gov't official	___	___	___	___	___
Signed petition	___	___	___	___	___
Attended meeting	___	___	___	___	___
Joined protest group	___	___	___	___	___
Organized protest group	___	___	___	___	___
Other (specify)	___	___	___	___	___
	(3/62-71)	(4/68-77)	(5/68-77)	(6/68-77)	(7/68-77)
	AC	MR	TK	TN	IN

(79-80)

11. [*Ask only if disturbed by one or more major source*]

Which of the following actions have you considered to avoid unwanted noise? Have you taken any of them?

[*Read Categories*]

	Considered (1)	Taken (2)	
Keep windows closed	___	___	
Install air conditioning	___	___	
Install extra insulation	___	___	
Keep storm windows on	___	___	
Install special glazing	___	___	
Construct barrier (e.g. fence)	___	___	
Plant trees	___	___	
Other (specify)	___	___	(1/44-51)

12. [*If aircraft noise not mentioned (Q's 2a/2c)*]

[*Use CARD C*]

You haven't mentioned noticing the sound of aircraft. Because we are quite near to a flight path here, I'd like to know how you rate the sound of aircraft in this neighbourhood.

Rating (EA-ED)_____ (1/52)

13. [*ALL RESPONDENTS*]

a. Do you notice any effects from aircraft other than noise?

(2) yes _____

(1) no _____ (1/53)

b. What are they?

smoke/fumes	___	
landing lights	___	
T.V. interference	___	
house vibration	___	
other (specify)	___	(1/54-58)

9

14a. Do any other aspects of aircraft or airport operations concern you?

(2) yes ____ (1/59)

(1) no ____

b. What are they?

fear of crashes ____ (1/60-61)

other (specify) ____

c. How concerned are you by this?

[*Read categories*]

(1) slightly concerned ____
(2) moderately concerned ____
(3) considerably concerned ____
(4) extremely concerned ____ (1/62)

15a. Do you think sufficient is done to reduce the adverse effects of aircraft?

(1) yes ____ (3) don't know ____

(2) no ____ (1/63)

b. What do you think should be done?

_____ (1/64)

_____

_____

16a. Overall, do you think the benefits of air transportation to society outweigh the disadvantages experienced by people living near airports.

(1) yes ____ (3) don't know ____

(2) no ____ (1/65)

b. To what extent do the disadvantages outweigh the benefits?

[*Read categories*]

(1) greatly ____
(2) considerably ____
(3) moderately ____
(4) slightly ____
(5) equal ____ (1/66)

And now a few questions about yourself.

17. [*DO NOT ASK*]

Sex (1) Male _____ (2) Female _____ (1/67)

18. What level of education have you completed?

(1) Some public school _____
(2) Public school graduation _____
(3) Some high school _____
(4) High school graduation _____
(5) Some university or college _____
(6) University or college graduation _____
(7) Post-graduate work _____ (1/68)

19. How old are you? _____ years (1/69-70)

20a. Do you have children living at home?

(2) yes _____
(1) no _____ (1/71)

b. What ages are they?

_____ (1/72-74)

21a. What is your main occupation, (that is what sort of work do you do)?

_____

b. What sort of business or industry do you work in?

_____ (1/75-76)

c. Is that in anyway related to aircraft or airport operations?

(2) yes _____
(1) no _____ (1/77)

22a. What is the main occupation of the principal wage earner (that is what sort of work does he/she do)?

_____

b. What sort of business or industry does he/she work in?

_____ (1/78-79)

c. Is that in anyway related to aircraft or airport operations?

(2) yes _____
(1) no _____ (1/80)

11

23. If employed outside the home, how would you rate your place of work for noise?
[*Read Categories*]
(1) very quiet ____
(2) fairly quiet ____
(3) average ____
(4) fairly noisy ____
(5) very noisy ____
(6) not applicable ____ (2/10)

24. In general how sensitive are you to noise?
[*Read Categories*]
(1) not at all ____
(2) a little ____
(3) moderately ____
(4) considerably ____
(5) extremely ____ (2/11)

25. Please indicate which range most closely describes the income before taxes of this household in the past year?

[*Use CARD I*]

(1) Less than $5,000 ____
(2) $ 5,000 - $10,000 ____
(3) $10,000 - $15,000 ____
(4) $15,000 - $20,000 ____
(5) $20,000 - $25,000 ____
(6) $25,000 - $30,000 ____
(7) More than $30,000 ____
(8) don't know ____ (2/12)

26. How many hours do you normally spend at home each day?

	(1) less than 10	(2) 10-15	(3) 15-20	(4) more than 20
Weekdays	____	____	____	____
Weekends	____	____	____	____

(2/13-14)

27. In the summer, how many hours do you normally spend outside at home?

	(1) 0	(2) 1-2	(3) 3-5	(4) 6-10	(5) more than 10
Weekdays	____	____	____	____	____
Weekends	____	____	____	____	____

(2/15-16)

28. If noise levels were reduced, would your use of outdoor space increase?

(2) Yes ____
(1) No ____ (2/17)

29. Do you rent or own your residence?

(1) Rent _____

(2) Own _____ (2/18)

30. How long have you lived in this house/apartment? _____ (2/19-21)

31a. Have you ever considered moving to a quieter neighbourhood to avoid unwanted noise here?

(2) Yes _____

(1) No _____ (2/22)

b. How much longer do you expect to stay in this house/apartment?

_____ (2/23-25)

32a. On average how often do you or other members of the household travel by plane in a year?

(1) never _____
(2) less than once a year _____
(3) once or twice a year _____
(4) several times a year _____ (2/26)

b. On average how often do friends or relatives travel by plane to visit you in a year?

(1) never _____
(2) less than once a year _____
(3) once or twice a year _____
(4) several times a year _____ (2/27)

33a. Would you be willing to have a noise monitor on your property for a 24 hour period some time during the next month?

(2) yes _____

(1) no _____ (2/28)

b. Times when not convenient _____

_____

c. Phone number _____

13

The following questions concern the type of dwelling you live in. Your help in filling them out is appreciated.

34. Building construction:

a. Number of stories in building _____ (2/29)

b. Building material:

(1) Brick ____
(2) Frame ____
(3) Stucco ____
(4) Asbestos panels ____
(5) Other (specify) ____ (2/30)

c. Type of windows:

(1) Single pane (openable) ____
(2) Thermal pane (not openable) ____
(3) Two panes (e.g. aluminum combination storms-openable) ____
(4) Double glazing (approx. 4" between panes, not openable) ____ (2/31)

d. Air conditioning:

(1) Central ____
(2) Window unit ____
(3) None ____
(4) Don't know ____ (2/32)

35. Type of dwelling unit:

(1) Apartment ____
(2) Flat ____
(3) Row/Townhouse ____
(4) Semi-detached ____
(5) Detached ____ (2/33)

36. If an apartment or flat, which floor? _____ (2/34)

37. Date _____ (day/month) (2/35-38)

38. FINISH TIME _____ (2/39-42)

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39a. Did aircraft noise interfere with interview?

(2)yes _____

(1)no _____ (2/43)

b. How often did it interfere?

(1) once _____

(2) two or three times _____

(3) several times _____

(4) almost continuously _____ (2/44)

c. Where was interview conducted?

(1) indoors _____

(2) outdoors _____ (2/45)

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